POWER

Volume 55 New York, January 3, 1922 *Number* 1

A Happy New Year!

TO all of its friends, and to all of its enemies, if it has any, *Power* extends a Hearty Holiday Greeting, coupled with the sincere hope that the New Year may bring to them a full measure of prosperity and happiness.

If I have made any resolutions, I am not going to tell of them until I find out whether they materialize. The editorial staff of *Power* has, however, some well-defined plans for the coming year, which have crystallized sufficiently to be expressed in promises.

First of all, we are going to try to be more and more useful to the busy practical man. The development of power-plant engineering is so rapid, the new ideas involved in the designs of the latest plants so numerous, the necessity of economy so increasingly pressing, the new devices for the use of the power-plant engineer so many, and all of these so provocative of literature, that the man to whom knowledge of them would be most useful is unable to keep up. It is our function and privilege to present the best of this information in a concise, easily assimilated form, to tell the story of current progress in the language of the engine and boiler room, and to interpret the fundamentals of the processes which they are conducting in a way that the practical man can understand and the busy professional man can stop to read.

One of the good things, which begins in this issue, is a series of articles on The Steam Engine Indicator. This will explain the use of the instrument upon the steam engine itself more exhaustively than any previous treatment, with directions for setting different types of valves by its use, and will also consider its application to ammonia and other compressors, pumps, internal-combustion engines, etc., and give directions not only for computing the horsepower, but for the analysis of the diagram for heat-exchange losses, the computation of the effective thrust on the crankpin, the effect of the momentum and inertia of the moving parts as affecting regulation, quiet running, etc.

We have also in hand articles by W. F. Osborne, on Fuel Oils and Lubrication; by Eustis Thompson, on Turbine Governors and Their Adjustment; on the Unaflow engine, by its inventor, Professor Stumpf; an article on the use of very high steam pressures, by O. H. Hartman, a series of articles by an experienced boiler inspector on the causes and analysis of boiler explosions.

We are going to continue to devote increased space to Practical Letters, Correspondence, Questions and Answers, and to the practical interpretation of passing events.

We prefer to be judged upon performance rather than promise. Our purpose and ambition is to be of real service to everybody who is interested in the design and operation of power plants. If there is any way in which *Power* can be made more useful to you, more adapted to your needs and interest, it will be a real favor if you will make it known.

F. R. Low

The Year's Progress in the Power Plant Field

Boiler Efficiencies of 90 Per Cent When Burning Pulverized Coal, Seven Notable Steam Plants Put Into Operation, Unusual Interest in Hydro-Electric Development, and 220,000-Volt Electric Power Equipment Are Some of the Outstanding Features of the Year 1921

A YEAR of readjustment and loss, fraught with labor troubles and dropping prices, coupled with high cost of production, high freight rates and the dallying tactics of Congress in failing to pass legislation that would tend to stabilize business and restore confidence, has made 1921 a lean year. Retrenchment has been general and with it naturally a lack of funds for experimental work, the pioneer in development and progress. With the close of the year came the first harbingers of more prosperous times. Inquiries have been numerous, and the fact that recently business conditions have been slowly improving, indicates that the crisis is past. The trend is upward, but just how soon conditions will revert to normal will depend on the elimination of the profiteer, the universal effort made to restore efficiency and conservatism, the will to work and the encouragement that proper legislation may give by lessening some of the burdens that are now handicapping industry and restricting the new financing that will be necessary for expansion.

Few Fundamental Developments in Power Plant Practice

OUTSIDE of stokers, where the application of forced draft to chain grates and a conveyor type of stoker has been perfected and established during the year, there are few fundamental developments to report. In power-plant equipment in general there have been improvements in details affecting reliability and economy, and with these factors in view there has been noticeable improvement in instruments, meters and in methods of combustion control. In boiler installations completed during the year, greatly increased furnace volumes are in evidence, the question of suitable furnace refractories has become urgent, there has been a marked tendency toward the use of steel in economizers and in other equipment, such as steam turbines, where the operating conditions impose severe stresses. To lessen scale troubles and maintenance and to maintain uniformly high efficiencies at the high ratings prevailing, there has been an increasing demand for evaporator plants to supply pure water to the boilers. Much more attention is being paid to the heat balance of the station. The interest in this subject has become of such importance that one whole session of the recent A. S. M. E. convention was devoted to a discussion on the heat-balance systems used in four large stations (see *Power*, Dec. 20, 1921).

Perhaps the greatest activity has been in the hydraulic field. In the sixteen months following the passage of the Federal water power act there have been filed with the Federal Power Commission 260 applications involving over sixteen million horsepower, which is nearly twice the existing capacity in water-power plants. In the same period 30 licenses were granted covering 1,269,000 hp., and 24 preliminary permits involving 1,280,000 hp. It is not to be anticipated that this enormous development in water power under contemplation will be carried to completion in the near future, but with the return of normal business conditions and industrial expansion, great activity in this field is a foregone conclusion. In the application of hydraulic turbines there is a strong tendency toward the use of the vertical Francis type for heads up to 800 feet.

In the steam plant the trend of the last few years toward higher pressures and superheats has been halted for the time being. While, theoretically, efficiency increases with the steam temperature and pressure, it has been found in practice that fixed charges, maintenance and reliability have an important bearing on results. In certain leading plants completed during the year steam temperatures of 600 deg. F. and under have been preferred to temperatures approaching 700 deg. developed in older stations, and for the same reason simplified operation at more conservative ratings is now considered better practice. The trouble has not been so much with the turbine nor the boiler, but in refractories used in the furnace, in valves, expansion joints and pipe lines. Temporarily, these accessories seem to be the weak link in the chain. These difficulties have been sufficient at least to delay the upward trend in pressure and temperature, and there is a sentiment in some quarters that we have perhaps approached too closely to the maximum for our present materials.

In Europe, where economy has been more persistently sought, owing to a less abundant supply of fuel and its higher cost, word comes of two recent stations, one the North Tees Station in England and the other the Superpower Station in Paris, in which steam temperatures of 700 deg. in one case and slightly more in the other, exceed our highest mark and a pressure of 450 lb. in the English plant is a considerable step in advance.

Progress in Utilizing Boiler Fuels

IN THE final layouts of plants the fuel situation, with its uncertainties, during the last year has had a bearing. The addition of accessories to improve economy depends largely on their cost relative to the price of fuel. A continued drop in price or a resumption of the abnormal charges of a year ago could not be predicted. Legislation was instituted to guard against such a contingency by insuring regulation of the industry or at least making public the facts concerning production, costs and sales. The coal operators have been successful so far in blocking this legislation, as a review of the vicissitudes met by the Calder, Frelinghuysen, LaFollette, Newton and Kenyon bills will corroborate, but some of this legislation is still on the calendar and will serve as an excellent club that may be raised at any time sentiment in the Senate favors such action.

Owing to the business depression, coal production has been far below normal and so little has been placed in

storage that the Government has been collecting data from consumers to serve as a guide to the buyer and perhaps forestall a possible shortage in the winter months, which a sudden resumption of business activity might precipitate. Because of the low demand competition has existed between bituminous producers so that for the greater part of the year it has been a buyer's market in which the consumer could insist on more careful preparation and select the coal best adapted to his conditions. A careful analysis of facts will show that coal costs approaching pre-war figures, except in the disposal of so-called "distress" coal, is wholly out of the question, at least for some time to come. Transportation expense, and the low "load factor" of the industry, due to extreme seasonal variations in demand and production, prohibit very cheap coal.

Interest in powdered coal has been increasing. Satisfactory results have been obtained in the large boilers at the River Rouge plant of the Ford Motor Company, and from the Lakeside plant in Milwaukee comes the report of efficiencies running close to 90 per cent. This figure, of course, expresses the over-all economy of boiler, furnace, superheater and economizer, with no deductions for auxiliaries. Continued operation has not brought forth the serious difficulties predicted. In some of the trial installations slag washed away the furnace lining and was difficult to remove from the furnace. These troubles have been overcome and a furnace developed which for days may be operated continuously at 250 per cent of rating with only a limited amount of ash in free form accumulating in the bottom of the furnace, which can be removed while the furnace is in operation.

Continued experiments have also indicated that to be burned successfully, the coal need not be so fine as usually specified and that it may contain with impunity moisture up to 7 or 8 per cent; there is, however, some difference of opinion on this point. Coal with a moisture content of 11 per cent has been burned, but the experts do not recommend so much moisture for a steady diet, if mechanical troubles such as packing in storage and transportation are to be avoided.

An interesting addition to the information on the subject is the experience of the Philadelphia Rapid Transit Company in burning pulverized anthracite culm in the Mt. Vernon Street Station, a hand-fired Corliss-engine plant. The hard and abrasive qualities of the anthracite made milling more difficult, increasing the maintenance and reducing the capacity to about 50 per cent of that for bituminous coal. The low volatile and high ash content also introduced difficulties, such as the installation of an oil-burning system to insure rapid ignition when putting a boiler into service and to act as a relay in case of interruption to the coal supply.

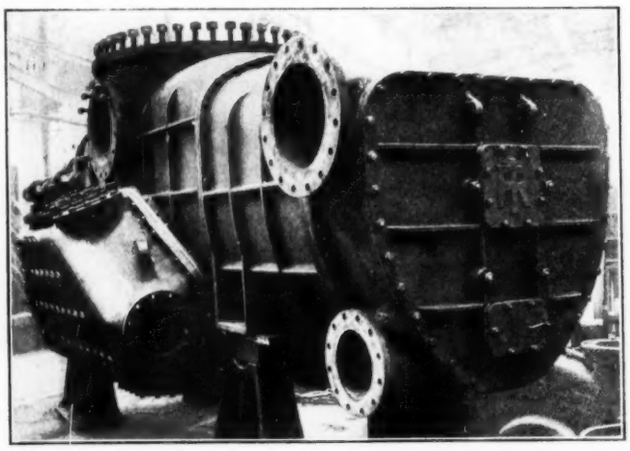
No special advance has been recorded in the recovery of by-products from raw coal. The plants now engaged in this work are proving successful, and there are indications of future extensions and developments, but in times when money is more plentiful, as the cost of an installation of this character runs up into large figures.

That the use of lignites is not increasing is not due to lack of knowledge of how this fuel should be burned. Past records show that combustion rates on chain grates as high as 60 lb. per sq.ft. per hour have been obtained, and with lignites containing 25 to 30 per cent of moisture combined efficiencies fell within the entirely creditable range of 69 to 72 per cent. Probably the true reason for the slow development of this natural

AEROPLANE VIEW OF THE QUEENSTON DEVELOPMENT OF THE ONTARIO HYDRO-ELECTRIC POWER COMMISSION
This plant will ultimately contain nine 45,000-kva. units. The first machine is about ready to go in service.

resource is the location of much of the lignite in regions of the West and Southwest, where it must compete with coal in proximity and with oil and gas at comparatively cheap rates. Storage difficulties and rapid deterioration make it necessary to burn lignite soon after it is removed from the ground and therefore at a comparatively short distance from the mine.

It is generally conceded that our limited supply of oil should be reserved for use on navy and merchant ships, where its advantages over coal are much greater than



INGERSOLL-RAND SURFACE CONDENSER
Tubes are arranged in a heart-shaped shell. External air cooler shown on left-hand side.

in the generation of steam in the stationary plant except in a few favored locations. The price of oil to the power plant is usually based on the competitive cost of coal, but the amount available and the quality depend largely on the demand by the automotive engine for gasoline and lubricating oil and the extent to which cracking is carried.

Owing to the shutting down of industrial plants using oil and the comparative idleness of the Navy and the merchant marine, the tank capacities of the oil companies became filled and it was inevitable that prices should drop, reaching exceptionally low figures during the greater portion of the year. Lately, however, there has been a rise which will continue with revival in business and bring back the inevitable shortage of recent years. At the present high rate of production it has been found that oil represents only one per cent of the coal consumption for power purposes. Even if this rate could be maintained, it is evident that oil is a mere incident in our fuel supply for stationary boilers and incidentally it is not likely that the sad experience of two years ago along the Atlantic Seaboard will be repeated, where the change from coal to oil was scarcely under way before the rise in price made it necessary in many cases to reverse the process.

Before passing on, mention should be made of the Trent process in which oil is used to recover high-grade coal from coal waste. The process consists in agitating together powdered coal, water and oil. The oil selects the coal particles, excluding for the most part the water and ash. This process has been developed to where coal is being produced for domestic use, and the indications are favorable that further development will extend this process to the recovery of coal for industrial purposes.

Another fuel in which there has been great development in the method of its burning is blast-furnace gas. Owing to irregularities in the volume of supply, much of this gas has been wasted to atmosphere. On account of the low heat content it is not profitable to store the gas, so it must be burned as it comes and at the low points of supply must be supplemented by other fuels burned in the same furnace or in separate units as conditions warrant. To burn the gas under conditions of varying quantity and pressure has required the development of special designs in gas burners, combustion chambers, baffling of the boiler and various other arrangements.

Notable Steam-Power Plants Placed in Operation

TO SUBSTANTIATE remarks made in introductory paragraphs, it may be of interest to review some of the notable steam plants placed in operation during the year. A station attracting unusual interest has been the Colfax plant, near Pittsburgh, Pa., of the Duquesne Light Co., one of the most modern mine-mouth stations in the country, with both coal and water close at hand and in abundant supply. A single generating unit of 60,000-kw. capacity, consisting of a three-cylinder cross-compound turbine driving three 20,000-kw. 12,000-volt generators on individual shafts, is now installed, a second unit of the same capacity is being installed, and the station eventually is to contain six of these machines. Seven boilers of the cross-drum type, each having 20,876 sq.ft. of heating surface, supply steam to the first turbine. An exceptionally high setting provides a furnace volume of 0.345 cu.ft. per sq.ft. of water-heating surface. Cheap fuel with low transportation cost has eliminated economizers. The heat balance of the station is maintained by means of a house turbine exhausting into a barometic condenser which is used as a feed-water heater. To secure the greatest reliability, with due regard to economy and simplicity of design, a steam temperature slightly under 600 deg. F. was selected, and it was considered that the lowest yearly cost in the boiler room would be obtained by operating at 200 to 225 per cent of normal rating.

At the Delaware Station of the Philadelphia Electric Co. a steam temperature of approximately 600 deg. is again in evidence. Boiler operation is at 250-lb. pressure, the superheat ranging from 170 deg. F. at normal rating of the boiler to 220 deg. at a maximum rating of 330 per cent. The average steam temperature in the boiler will thus be close to the figure given and at the turbine throttle will approximate 575 deg.

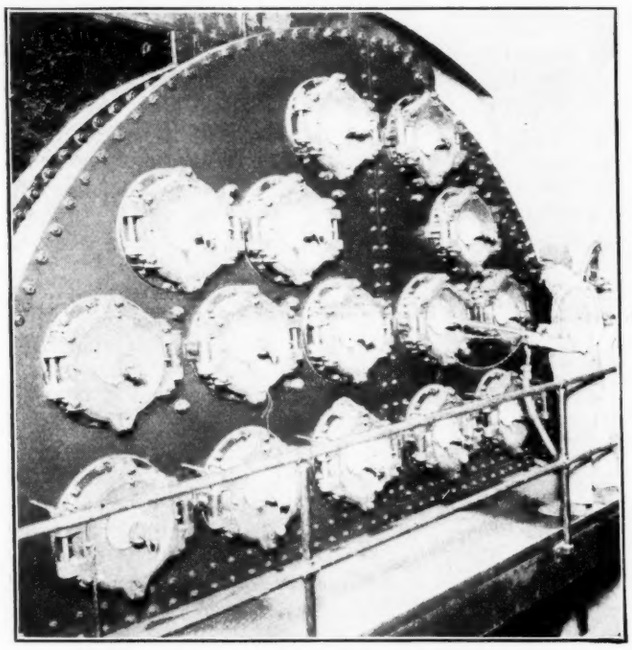
This plant is to contain, ultimately, six 30,000-kw. units, two now are installed, with four boilers per unit, each having 15,080 sq.ft. of steam-making surface, which increases to 19,030 sq.ft. when including the integral economizer. A furnace volume of 0.48 cu.ft. to 1 sq.ft. of water-heating surface, is provided. This large furnace volume may be partly credited to the composite design of furnace, which provides for the burning of four different fuels: Bituminous coal on stokers, powdered bituminous coal, powdered anthracite, and oil. Duplicate auxiliary units driven by steam and electrically, afford a choice for maintaining the station heat balance.

Another mine-mouth plant designed for an ultimate capacity of 100,000 kw. and now containing two 20,000-kw. units is the Seward station of the Penn Public Service Corporation. The steam temperature here is 596 deg. F., made up from a pressure of 280 lb. and a superheat of 180 deg. at 200 per cent of rating. Three

cross-drum boilers of 16,000 sq.ft. each, employing superheaters but no economizers, supply steam for the two turbines. A furnace volume of 0.325 cu.ft. per sq.ft. of heating surface is provided.

The South Meadow plant of the Hartford Electric Light Co., Hartford, Conn., was put into service during the latter part of the year. This plant is laid out for 130,000 kw.; one 20,000-kw. unit has been installed and a second machine is on order. The plant will ultimately contain sixteen boilers of 14,000 sq.ft. of water-heating surface, two 20,000-kw. and three 30,000-kw. main units. Four boilers, each having 14,000 sq.ft. of water-heating surface, have been installed, operating at a pressure of 275 lb. gage and superheat of 225 deg. F., giving a total steam temperature at 200 per cent rating of 640 deg. F. Integral economizers of 20 per cent of the boiler-heating surface are installed, and provisions are made to install separate economizers should conditions warrant at some future time. A furnace volume of 0.45 cu.ft. is provided per square foot of boiler water-heating surface. The guaranteed water rate of the turbines at their most efficient load is 10.1 lb. per kilowatt-hour.

Another station that has been the center of considerable interest is the Hell Gate plant of the United Electric Light and Power Co., New York City. This plant



WORTHINGTON TUBE WASHER CLEANING TUBES OF 56,000 SQ.FT. CONDENSER UNDER FULL LOAD AND VACUUM

will have an ultimate capacity of 280,000 kw., consisting of eight 35,000-kw. turbo-generators. There will be 4 single-cylinder machines and 4 double-cylinder units. There will be 24 boilers of 18,900 sq.ft. of water-heating surface each, one-half of which is being installed at the present time, and the first two generating units have been put into service. The boilers are double-stokered and a furnace volume of approximately 0.4 cu.ft is provided per square foot of heating surface. No economizers are used, and the total steam temperature is approximately 600 deg. F.

At River Rouge, with its four great boilers containing, individually, 26,470 sq.ft. of steam-making surface, the largest for power purposes in the country, the temperature is again 600 deg., the pressure being 225 lb. and the superheat 200 deg. With an enormous furnace and vertical heating elements on either side, the boiler rises to the great height of 83 ft. above the ash floor. The furnace volume, approximating 0.5 cu.ft. per sq.ft. of steam-making surface, is larger than for the other plants mentioned, and naturally, as the fuels burned, powdered coal and blast-furnace gas, require such provision. When operating at a rating of 250 per cent of normal on coal alone, about 0.5 cu.ft. of furnace volume per pound of coal burned per hour is provided, and this is based on a liberal allowance as to the quantity of fuel required.

Another powdered-coal plant designed specifically for this fuel is the new Lakeside plant of Milwaukee, in which 40,000 kw. of an ultimate 200,000-kw. plant has been placed in operation. Here an operating pressure of 265 lb. gage and a superheat of 200 deg. gives a final steam temperature of 611 deg., which hugs the 600 mark previously mentioned. The boilers are eight in number, with 13,060 sq.ft. of heating surface, and normal operation will be at 200 per cent of rating. A furnace volume of 7,030 cu.ft. reduces to 0.54 cu.ft. per sq.ft. of heating surface, and at 200 per cent of rating provides 0.74 cu.ft. per pound of Illinois coal burned per hour. From past experience and test work at Oneida Street Station, this allowance is required to insure perfect combustion and to eliminate slag formation. The station has economizers, and in common with other leading plants special attention has been given to the heat balance.

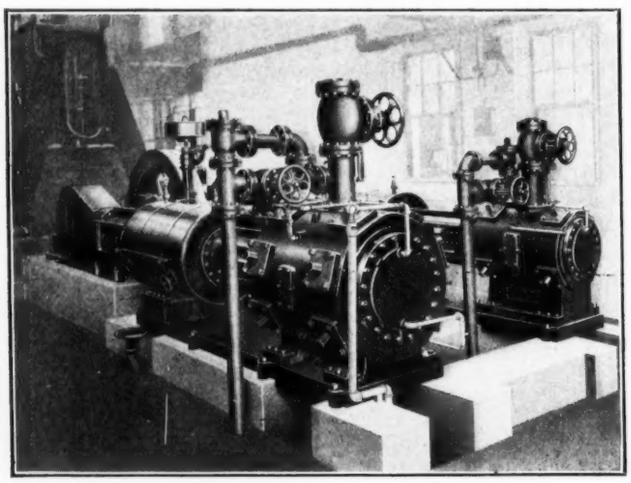
Of plants made ready for service last year, it has remained for Chicago to take the lead in pressure and final steam temperature in the new Calumet Station of the Commonwealth Edison Company. The seven 15,089-sq.ft. cross-drum boilers installed to serve two 30,000-kw. turbines, have been built for a pressure of 350 lb. and 250 deg. of superheat, giving a final steam temperature of 685 deg. Operation may not be quite up to these limits, but the plan is to supply steam to the turbines at 300 lb. pressure and 225 deg. of superheat, or in other words, at a final steam temperature approximating 650 deg. Of further interest economizers with steel tubes and steel headers are being employed.

A progressive step is the installation of forced-draft chain grates, two per boiler, with a total area bearing a ratio to the steam-making surface of 1 to 40. With headroom of 20 ft. from the grates to the tubes, a furnace volume of 18 cu.ft. per square foot of grate area has been obtained. In this station it has been estimated that the fuel expense will amount to about 86 per cent of the generating cost and that a kilowatt-hour will be produced on 19,000 B.t.u.

Superpower Report Completed

IN CONNECTION with the generation of power, an event of the year was the completion of the Superpower report by the United States Geological Survey. In the report the investment in generating and transmission facilities for the Superpower System is estimated to exceed a billion dollars, of which nearly one-half represents existing facilities that would be incorporated in the system, including 80 per cent of the steam-electric stations and all the efficient water-power developments in the zone. To supplement the older plants, it is the intention to locate new base-load steam-electric stations

at advantageous load centers and to develop additional water power, particularly on the St. Lawrence, making it possible to increase the load carried by hydraulic plants from 15 per cent in 1919 to 21 per cent in 1930. Bringing St. Lawrence power over long-distance transmission lines to the system would save, according to estimate, over $11,000,000 a year in the cost of energy, and the total investment to use power purchased from this source would be $25,000,000 less than the cost of steam plants to render equivalent service. The report



WORTHINGTON DUPLEX UNAFLOW STEAM ENGINE DRIVING CROSS-COMPOUND AMMONIA COMPRESSOR

proceeds with the opinion that it would be profitable to electrify about one-half of the railroads in this zone, the annual saving over steam operation approximating $81,000,000. The coal saving by electrification plus that made possible by improved operation in the steam plants retained in the system, was placed at 50,000,000 tons.

One of the big problems in coal conservation to be solved by the Superpower System or by the individual central station is to care for the heating load of its customers economically. Burning coal for heating without recovering electrical energy is a most wasteful practice, particularly if a balance between the two loads can be approximated. From Rochester, N. Y., comes the suggestion of decentralized plants or units consisting of non-condensing turbo-generators located on the heating system at such points as may be most advantageous for the economic distribution of the exhaust steam. The installations are to be semi-automatic in character with periodic inspection, so that one man may supervise the operation of several plants. Safety devices are to be provided to guard against damage by automatically shutting down the machine in emergencies, and, in this event a reducing valve is to be provided to bypass the steam into the low-pressure system.

Steam Boilers and Superheaters Increasing in Size

TO SATISFY the demand for larger units in the field of steam generation, there has been a drift toward cross-drum boilers of the modified Stirling type with bent tubes, so that the boilers can be knocked down and assembled on the job. Sizes have been increasing. Depending on the capacity of the plant or the unit division, the surface per boiler in the leading stations of the country ranges from 14,000 to 20,000 sq.ft., with steam capacities ranging from 125,000 to 200,000 lb. per hour. There are, of course, larger boilers, such as those employed by the Detroit Edison Company and the big River Rouge boilers, which, with a surface of 26,470 sq.ft., hold the record for power generation. To generate steam for heating purposes, a boiler exceeding all previous records, with 29,820 sq.ft. of surface, has been installed in the Congress Street heating plant of the Detroit Edison Co. It is a double-ended boiler of Connelly design, supplying steam at 75 to 160 lb. pressure.

Pressures and temperatures have been touched upon previously and mention made of the high cost of fuel, which, in conjunction with the higher flue temperatures resulting from operation at high ratings and steam at higher temperatures, has made the economizer a more profitable investment, although the economical advantages have been offset to a certain extent by the higher cost of the economizer itself. For the higher pressures wrought-steel tubes and headers are apparently favored over cast iron, as they are more compact and are considered safer. To reduce air leakage and radiation, the integral type is becoming more common.

Of late the separately fired superheater is being revived and suitable designs are being considered. The need arises from fluctuations in the rate of steaming in the larger boilers and the resultant variations in the superheat and the temperature of turbine parts. While the separately fired superheater is not so efficient as the integral superheater, it is open to regulation either to give a wide range of superheat or to keep a constant temperature of the steam regardless of the amount. In the integral superheater there has been improvement, and new types have been brought out, such as the superheater used in the River Rouge boilers so recently described.

Stokers Show Renewed Interest in Chain-Grate Types

DEVELOPMENTS in the stoker field have not been so marked as would have been the case had general business conditions necessitated more activity. Nevertheless, a noticeable trend has been the rapid acceptance of the forced-draft traveling grate as a satisfactory central-station unit. There have been no less than three companies, heretofore engaged in building exclusively natural-draft stokers, that have entered this field, in addition to the four others that were previously engaged. Its superior qualities of increased economy over a wide range of load, increased capacity and flexibility, ability to burn poor grades of coal and positive control of all conditions, have so far outweighed the disadvantages at first encountered, but now largely corrected, of hard-slag formation on the bottom rows of tubes, air leakage, holes in the fire and secondary combustion, that the number of installations has increased rapidly.

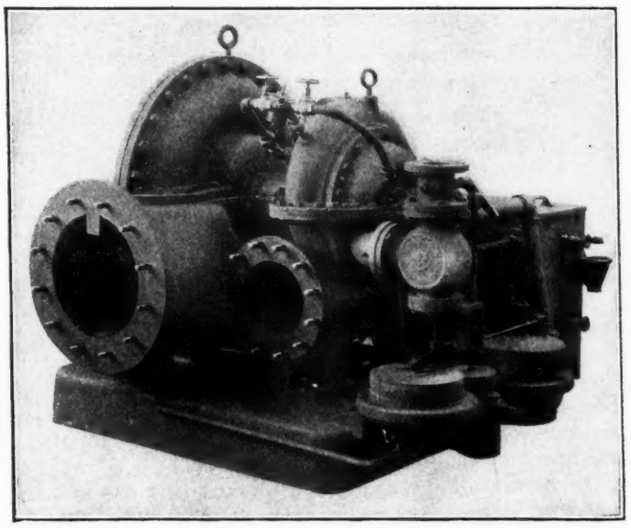
In a new stoker now serving its apprenticeship in an initial installation, the air space is practically as large as employed in the natural-draft stoker. It is reported that air velocities, even at 300 per cent of rating, do not exceed 40 ft. per sec., that there is no special difficulty from sifting and that it is possible to operate up to 175 to 200 per cent of rating on natural draft.

An outstanding feature of the year is the employment by three different companies of the large forced-draft chain grate having uninterrupted surfaces as wide as

24 ft. and up to 20 ft. long. The impulse back of this design was the failure of furnace refractories to stand up under the high-temperature conditions of excessive boiler ratings. It has been exceedingly difficult to maintain outside boiler walls and almost impossible to maintain center or partition walls between twin stokers under a single boiler. Melting temperatures are developed, particularly with forced draft, so the center wall had to go and a stoker of twice the normal width became essential.

Owing to inadequate refractories for side walls and arches it has been impossible to maintain the high rates of combustion possible with the forced-draft stoker. Maintenance becomes excessive for an average rate exceeding 50 lb. of coal per square foot of grate. Average practice then approximates this rate, which is considerably in excess of the maximum obtainable from natural draft. Experience at Cleveland, given recent publicity, offers a possible solution of the refractory problem. Here furnace linings of monolithic construction made up of ground firebrick mixed with high-temperature cement to form a plastic mass that can be pounded onto the side walls to a depth of eight or ten inches, have given excellent results under operation at high rating over a period of several months. In the arch, layers of this ganister are alternated with the tile, so that no crevises are left for the admission of hot gases or flame to start disintegration.

A new underfeed stoker has been added to the long list already in the field. Distinguishing features are a



RATEAU BATTU SMOOT 300-HP. TURBO-BLOWER WHICH OPERATES AT 20,000 R.P.M.

horizontal fuel bed giving positive control of the fire, adjustable air admission over the fuel bed through ports in the front wall, adjustable stroke and auxiliary pushers with independent adjustment. An existing type of side-dump underfeed stoker has been improved by the addition of sloping combustion grates and hand-operated dump plates.

Methods of Combustion Control Improving

LATEST practice in underfeed-stoker installations is to control the positions of the uptake dampers by a master regulator under the control of the steam pressure and flow. This tends to give uniform conditions for all boilers and to adjust for variations in the individual fuel beds, individual regulators operated by variations in draft over the fire, control the damper position in the forced-draft duct leading to the stoker windbox. Pressure control, tied up with the uptake damper system, or separate, may be extended also to the stoker and fan drives. Other new features are power-operated agitators in the base of the stoker hopper to prevent arching and packing of the coal, various new methods of preheating the air for boiler furnaces and the use of larger and better-protected ash hoppers.

A detail that has been more or less in evidence during the year is the use of hydraulic means for quenching and removing ashes. In some installations the ashes drop from the hopper into a tank of water and are picked out with a clamshell bucket; in others they drop into a trough filled with water and are drawn away by a scraper conveyor, while the simplest installation of the kind is a conduit at the bottom of the ashpits, through which a continuous flow of water carries away the ashes. When the water is available, this method seems to be very satisfactory.

"Vortical" combustion, or the burning of coal in suspension, has been advanced during the year, and there is now a commercial installation of a furnace being made.

Boiler Explosions Not So Numerous

PROBABLY because of business depression and the shutting down of so many plants, violent boiler explosions disastrous alike to life and property, were not so numerous as usual. There were a number of return-tubular boiler accidents resulting in fatalities, such as the explosions at Monterey, Tenn.; at Taft, Cal.; and at Lumber, S. C. In Mechanicsville, N. Y., another of these return-tubular boilers exploded from overpressure due to a defective safety valve. Fatalities of five and a property damage exceeding $40,000 mark it as the most serious explosion of the year.

Relative to boiler safety an event of the year was the first annual convention of the National Board of Boiler and Pressure Vessel Inspectors. This organization has now passed the preliminary stages and is functioning efficiently in the states where it is recognized, in carrying out the aims set forth in its preamble, of promoting greater safety to life and property by securing concerted action and maintaining uniformity in the construction, installation and inspection of steam boilers and other pressure vessels and their appurtenances, and to secure interchangeability between political subdivisions of the country. Thus the promotion of uniform boiler laws, uniform approval of specific designs and one uniform code of rules and one standard stamp to be placed upon all boilers are the primary objects. The A. S. M. E. Code has been adopted and is acceptable to the departments of seventeen states and twelve smaller political divisions represented on the board.

Steam-Turbines Have Not Increased in Size

IN STEAM turbines there are no outstanding developments, although much has been done to improve the designs of large machines by increasing the reliability and efficiency of operation. The use of steel and more rigid construction has apparently eliminated to a great extent the troubles from axial vibration and the variations in steam temperatures and volume due to changes in load. Better workmanship, more homogeneous material and improved operating methods contribute

to the reduction in accidents, although some of the units built during the war are still giving trouble.

Impulse turbines of many stages showing high economies have been brought out, of which the 3,000-kw. 40-stage turbines driving the blast-furnace blowers at River Rouge are an example. The use of such machines is determined by a balance between the gain in economy and the extra cost of construction and installation over standard turbines. It is evident that these machines can be considered only for installations where the load

I. P. MORRIS TURBINE CASING FOR ONE OF THE 55,000-HP. QUEENSTON UNITS

factor is uniformly high and the cost of fuel also high enough to warrant the additional initial investment.

There has been reported the development of a new design for units of capacities up to 30,000 kw. This turbine consists of a high- and a low-pressure element in independent casings. Each rotor is supported by its own bearings, and the two are connected together with a flexible coupling. Thrust bearings are provided on each rotor to maintain its proper location relative to the stationary parts.

There has been no increase in the size of turbine units, the 60,000-kw. compound machines and 45,000-kw. in a single cylinder still hold the record. Incidentally, a second unit of the latter capacity has been placed in service during the year at the Connors Creek Station. Units of 30,000 kw. have been more generally favored, as in most cases they permit a more flexible division of the station load, their economy is as high as that of the larger machine, and having been built in greater numbers, their construction and operation are more nearly standardized .

Conditions relative to steam pressures and temperatures have been previously covered. There is some indication toward higher speeds, and this is particularly true in Europe, where the lead also has been taken in steam pressures and temperatures. One of the late developments is the bleeding of steam from the lower stages of the main turbine units to maintain the heat balance of the station and to permit straight electric drive for auxiliaries. This method, succeeding the house turbine and heater condenser, has certain inherent advantages in that it is more economical and much simpler, although it does not afford the additional protection and convenience in starting up given by a separate machine.

During the year turbine lubrication has received more attention than ever before. While severe and diversified requirements complicated by wide variation in turbine lubricants and the disagreement of experts, the production and purchase of suitable oils has been difficult. As a result there is a strong movement toward formulating standard specifications for turbine oil and a demand for a simple method of testing, so that purchases can be checked and the effectiveness of filtering and purifying equipment followed in order to maintain the quality of the lubricant.

Not only in oil has there been a demand for standard specifications. Quite recently the Association of Edison Illuminating Companies has gone on record as favoring the preparation of a tentative draft of standard turbine specifications covering matters affecting operating performance, central-station design and operation and maintenance requirements, leaving improvements and features of construction to the builder, but suggesting close co-operation among all parties concerned. Methods of standard testing are being developed by the Power Test Code Committee of the American Society of Mechanical Engineers.

In small machines a new geared unit, consisting of an impulse turbine element mounted directly on the gear housing, has made its appearance. Report also has been made of a new mixed-pressure-turbine governor which, in addition to the equipment for high-pressure regulation, has a so-called selective mechanism between the oil-control cylinder and the high-pressure valve stem.

Few Changes Have Taken Place in Condensers and Auxiliaries

FEW changes in surface-condenser design have taken place, but a constant study of operation is being made to improve the efficiency. An old established company has entered the condenser field and is bringing out a surface condenser with varying tube spacing in a heart-shaped shell. At the top the spacing is greater to provide for the full volume of steam and in proceeding downward is reduced as the quantity of steam becomes less. This arrangement has been made to insure an even distribution of the steam over the tube surface, high steam velocities and rapid condensation. The external air cooler has been revived and consists of cast-iron grids with fins meshed together to give a maximum of cooling surface.

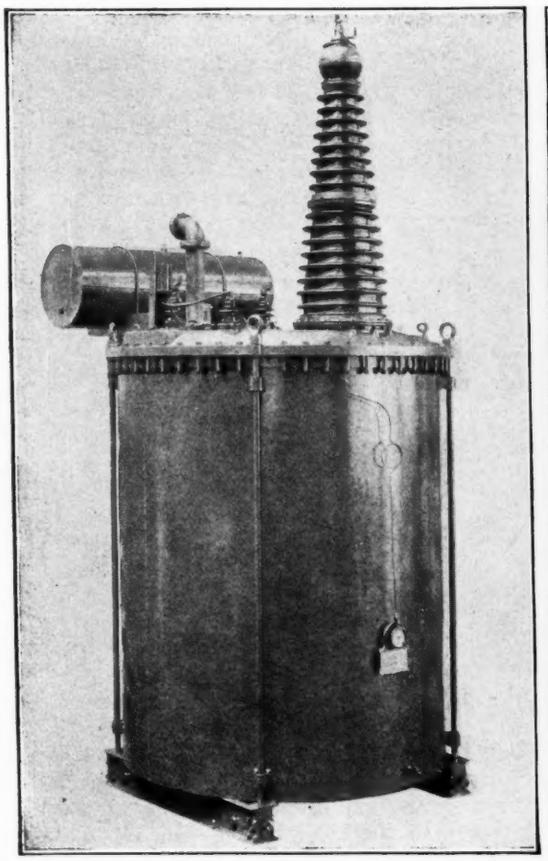
On account of their simplicity, increasing use is being made of steam ejectors, single- or two-stage, for the removal of air, in multiple units so that one or more may be operated in accordance with requirements, and to provide the necessary reserve in case of accident. Auxiliary open, vented heaters or surface heaters prevent the air from entering the feed-water system, this being of particular importance in preventing internal corrosion in wrought-steel economizers and other parts of the system.

Details of jet and barometric condensers have been improved and standardized. The former are being supplied in twin units to meet efficiently varying load conditions and temperature changes in injection water. As in the case of surface-condenser circulating pumps, one or both of the elements of the twin unit may be operated as required. Examples of particularly large installations of this kind are to be found in the Hauto plant of the Pennsylvania Power and Light Company, where

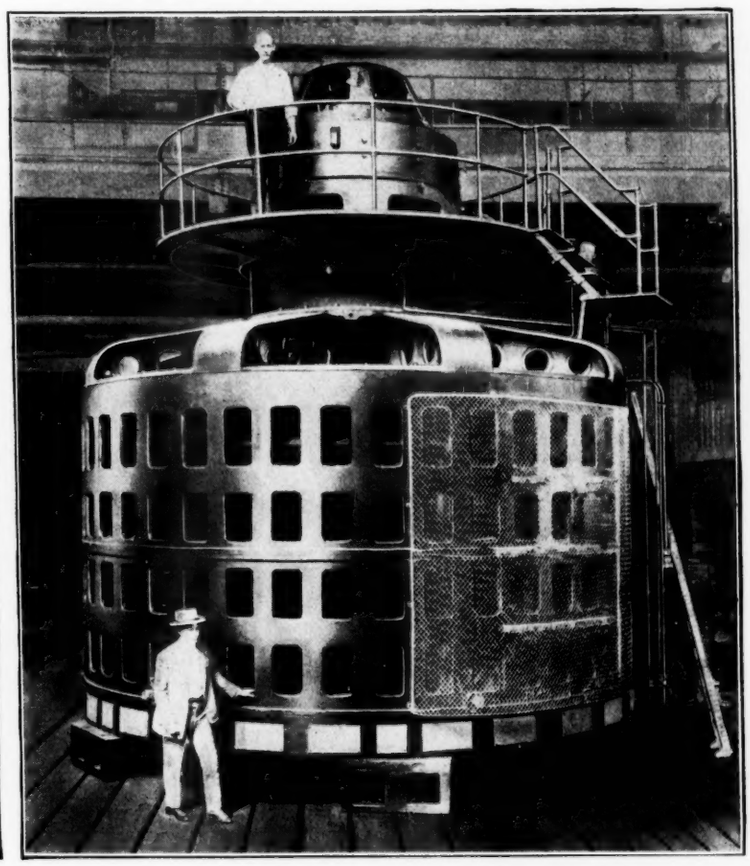
a twin unit with a removal pump capacity of 25,000 gal. per min. serves a 20,000-kw. turbo-generator, and at the Seward plant of the Penn Public Service Corp., where twin low-level jet condensers serve 20,000-kw. turbines. The water-removal capacity is 28,000 gal. per min., and air is drawn from each condenser by five out of seven steam ejectors per unit with condensers of the submerged mixing type.

During the year there has been considerable discussion on the continuous treatment of the cooling water makeup with hydrochloric acid to prevent scale formation in surface condensers used in connection with cooling towers or spray ponds. The high cost of this treatment led to the use of sulphuric acid in a similar way in the plant of the Arizona Copper Co. at Clifton. Good results are claimed at a cost of 60c. per kilowatt-year with the added statement that calcium and magnesium sulphates are less likely to corrode the condenser tubes than chlorides.

While on the subject of condenser cooling water, reference should be made to two records established during the year. To the Union Gas and Electric Co., of Cincinnati, goes the credit of making the largest installation of its kind in the world, that of sixteen traveling water screens having a screening capacity exceeding 200,000 gal. per min. and the abnormal length from center of 91 ft. to meet the great rise and fall of the Ohio River at this point. At the model industrial plant made ready for operation during the year by Dodge Brothers, in Detroit, is what is believed to be the largest cooling-tower installation ever made.



GENERAL ELECTRIC 220,000-VOLT, 8,333-KVA. TRANSFORMER



ALLIS-CHALMERS 35,000-KVA. WATERWHEEL GENERATOR FOR MOUNT SHASTA DEVELOPMENT

Steam Engines Show Renewed Activity

THAT the steam engine is declining in favor and perhaps has seen its best days is a popular conception which the recent analysis of the census in the Superpower Zone will go a long way toward refuting. Of the total industrial power used in this zone, aggregating over nine million horsepower capacity, exclusive of steam and electric railways and central-station lighting loads, two-thirds is privately generated and one-third purchased. In prime movers, excluding those in the central station, steam engines account for 68 per cent of the horsepower; steam turbines, 19 per cent; waterwheels, 8.5 per cent, and internal-combustion engines, 4.5 per cent. Thus there is every indication that the steam engine is still a big factor in the generation of power.

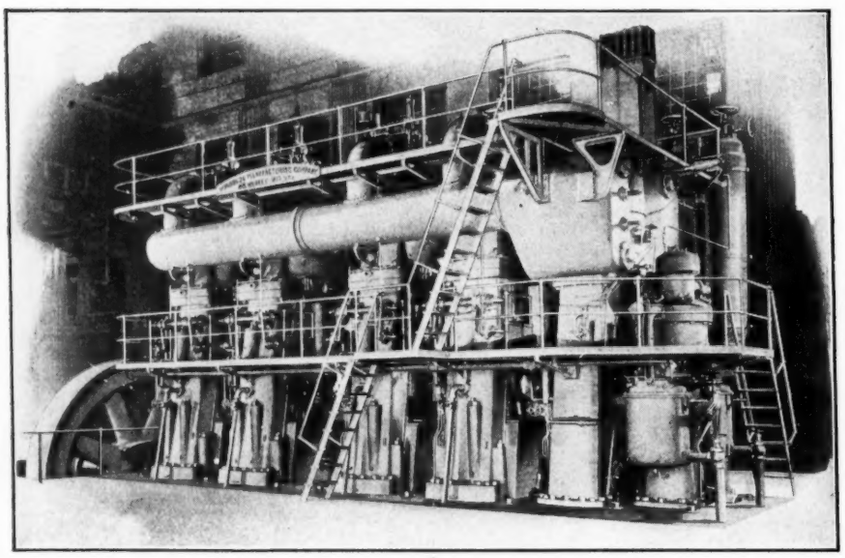
Owing to their particular adaptability to the refrigerating field there is every reason to expect a continued use of the more improved types of poppet-valve and unaflow engines. The last year has witnessed increasing use of the unaflow engine in municipal and other power plants where the load fluctuates through wide ranges, the reason being the flat steam curve characterizing this engine. During the last year approximately 40,000 hp. of unaflow engines were sold in this country. It is also popular for operation in connection with heating loads, running condensing during the warmer months. Sustained economy over a wide range of load and ability to handle heavy overloads have gained favor for this type of engine in the steel mills. An important installa-

tion during the year was that of two 5,000-hp. duplex unaflow engines for driving plate mills.

One of the largest engine-driven generating units installed within the last decade was placed in service recently in the plant of the Corn Products Co. in Kansas City. The unit consists of a horizontal twin tandem-compound drop-valve engine with two high-pressure and two low-pressure cylinders, 27 and 50 x 54 in., driving a 2,500-kw. alternator.

In the coal fields considerable activity in the installation of equipment is reported. One prominent manufacturer has built recently several large hoists equipped with cylindro-conical drums for rapid hoisting. Steam engines have been employed in some cases, and in others the drive has been induction motors or direct-current motors operated in conjunction with motor-generator flywheel sets.

Of other large reciprocating machinery of the year mention should be made of one of the largest air compressors on record using plate valves. This compressor,



NORDBERG 2,000-HP. TWO-STROKE-CYCLE DIESEL ENGINE FOR DRIVING AN ALTERNATING-CURRENT GENERATOR

which was installed for the Hollinger-Consolidated Gold Mines, Ltd., of Timmins, Ont., is a horizontal two-stage machine, 50 and 29.5 x 36 in., with the cranks coupled at right angles. It was designed to deliver 9,100 cu.ft. of free air per minute compressed to 105 lb. gage pressure. The drive is a 1,565-hp. synchronous motor of the revolving-field engine type with sufficient weight in the rotor at 125 r.p.m. to make it possible to eliminate the flywheel. Under the operating conditions given, the compressor has a piston speed of 750 ft. per min. and a volumetric efficiency approximating 92 per cent.

Unusual Pumps and Blowers Put Into Service

REVERTING to centrifugal equipment, probably the largest high-head pumping plant in the United States was installed by the municipal water works at Shenandoah, Penn. It contains two pumps, each designed to deliver two million gallons a day, against a head of 1,000 ft. A striking feature is that the pump has only three stages, with the abnormal lift of 333 ft. per stage, the efficiency under 1,000-ft. head being 62 per cent.

Another interesting pump of the year is a five-stage centrifugal unit built for the extremely high pressure of 350 lb. per sq.in. At 1,200 r.p.m. it has a capacity of 900 gal. per min. The pump is direct-connected to an eight-cylinder dual-valve gasoline marine-type engine developing 242 brake-horsepower at the speed given. It was designed as a reserve unit pending the completion of the water works at Ironwood, Mich.

A novel type of return-line vacuum pump may be added to the list of unusual pumps. It consists of an air pump that exhausts the air from the system, a centrifugal pump to remove the hot condensate and return it to a feed-water heater or hotwell and a steam turbine to drive the unit, all mounted on one shaft and assembled in the same casing. The air and condensate are separated in a receiver under vacuum before entering the unit.

Another outfit designed for the same purpose and made in considerable numbers during the year, consists of a motor-driven centrifugal pump and receiver equipped with a float. The pump draws water from the tank and discharges it back to the tank through an injector-type nozzle which creates the vacuum in the return line and pulls the air and condensation into the tank. A .vent connection allows the air to escape, and as the quantity of the water in the tank increases, the float rises, opening a balanced bypass valve on the discharge side of the system to deliver the surplus water to the feed-water heater.

Among the important turbo-blowers built during the year or under construction is to be found a 2,600-hp. machine which will operate at 9,000 r.p.m. without going through its critical speed. The blower has 3 stages and is designed to have a normal capacity of 15,000 cu.ft. and a maximum capacity of 20,000 cu.ft. of free air per min. at 41 lb. gage. The turbine is also a 3-stage machine and will operate on steam at 150 lb. at the throttle and exhaust against 25 lb. gage back pressure, the exhaust steam being used for process work. Three machines operating at 20,000 r.p.m. were built. Both turbines and blowers are single-stage machines. The turbines are capable of developing 300 shaft horsepower and operate non-condensing on steam at 100 lb. gage.

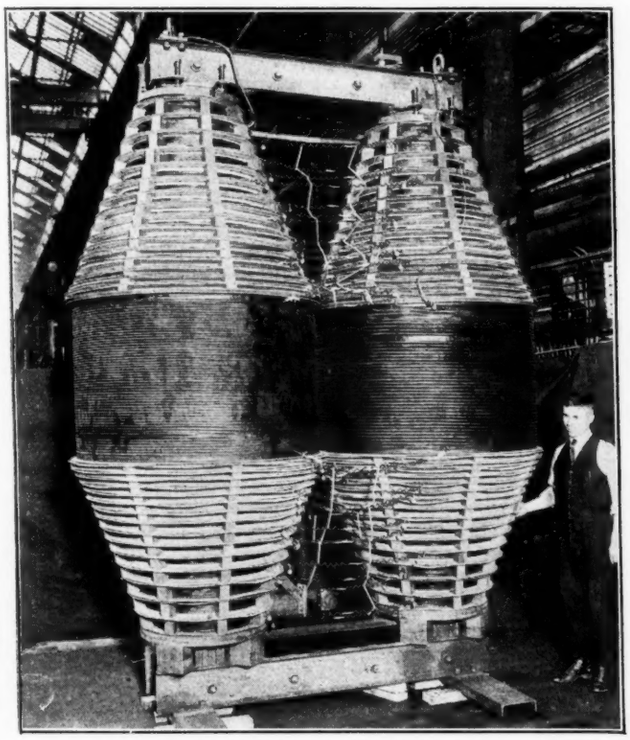
Intense Interest in Hydro-Electric Development

APPLICATIONS received during 1921 by the Federal Power Commission at Washington, exceed those for the last fifteen years. The number and the total capacity involved (over 16,000,000 hp.) have been given previous mention. All this activity, when considered in connection with the numerous projects of magnitude already under way or under consideration and the large plants completed for initial operation during the year, presages an epoch-making period in this field.

Niagara Falls offers possibilities for the ultimate development of 4,000,000 hp. without destroying the scenic beauty of the Falls. Of this only about one-sixth has been developed, although plans are under way to utilize a greater percentage of the maximum and in

particular to develop the lower river. The movement on foot to develop the St. Lawrence River is a project of even greater magnitude, involving the construction of two and ultimately three dams, with a hydro-electric station at each dam, and the recovery on conservative estimate of 4,000,000 kilowatts.

Of the larger applications upon which early action may be anticipated, mention should be made of the 75,000-kw. Great Falls project on the Potomac; the 500,000-kw. Delaware River development with a 100,000-kw. steam plant; the 2,500,000 hp. which the Southern California Edison Company proposes to develop on the Colorado River, and the addition to the Big



WESTINGHOUSE 1,000,000-VOLT TRANSFORMER

Creek series of another plant having an ultimate capacity of 150,000 kw.; the 400,000-hp. Kings River projects of the San Joaquin Light and Power Corporation; 66,000 hp. in the Hetch Hetchy project near San Francisco; 100,000 hp. on the Coosa River in Alabama; 60,000 hp. on the Roanoke River in Virginia; 30,000 hp. on the Dix River in Kentucky, and other installations too numerous to mention.

Typical plants under way are the Queenston development of the Hydro-Electric Power Commission of Ontario, where five 55,000-hp. reaction turbines operating under a 305-ft. head are to be installed, the first unit in which is about ready to be put into service; the Muscle Shoals development of four 30,000-hp. units at 95-ft. head, which has received so much publicity is still under discussion. Henry Ford has offered to take over the whole project, but has not been able to reach an agreement on terms with the Federal Government. Other typical plants are, the 60,000-kw. Catawba River and the 45,000-kw. Great Falls, S. C., plants of the Southern Power Co., and the several plants of the Pit River project in Northern California being carried out by the Pacific Gas and Electric Co., of San Francisco. It is expected that the complete series of two Hat Creek and five Pit River plants will add 600,000 hp. to the company's system. Features of this development will be the 220,000-volt transmission line, the seven-mile 3,000-sec.-ft. tunnel for Pit River No. 5 and the 40,000-hp. reaction turbines under 445-ft. head for the Pit River No. 1 plant.

One of the prominent plants put into operation during the year was Kern River No. 3 of the Southern California Edison Co. It contains two vertical-shaft 22,500-hp. Francis-type turbines, each operating under an effective head of 800 ft., the highest ever attempted with this type of wheel.

Two of the largest impulse-wheel-driven units in the world, rated at 30,000 hp. each and operating under 1,008-ft. head at 171 r.p.m., were installed in the new Caribou station of the Great Western Power Co., at Belden, Cal. Each unit consists of two independent wheels mounted on each side of the generator.

A recent and most important installation practically ready for operation is that of the two 40,000-hp. units for the Mount Shasta Power Corporation. The turbines are of the Francis single-runner reaction type operating under 421-ft. head.

It is thus evident that the size of waterwheels is still on the increase. By turbines of the year two capacity records were broken, and the Queenston turbines will exceed these records by a wide margin. Another tendency is the application of large reaction wheels to higher heads, Kern River No. 3 plant with its 22,500-hp. units holding the record so far at 800 ft. Although there is little information available so far on this late installation, leading builders are prepared to furnish large units of this type for heads probably up to 1,000 ft. High-speed single-runner vertical machines are favored for large powers, and improvement in design is centered upon obtaining not only high efficiency over a great range of load, but reliability and durability as well, as it is upon the latter features that the ultimate success of the hydro-electric development depends. These characteristics are possessed to a higher degree by the impulse turbine, although it is slightly less efficient and, being a slower-speed machine, is of larger size and more costly than the reaction turbine.

For regaining the energy from turbine discharge, two new types of draft tubes have been developed in addition to the White hydracone and the Moody spreading tube. A number of low-head installations have been made with the Nagler type of runner, and the Tefft conduit spillway proved so successful at the Mio Dam that it has been installed at the Junction Dam, the latest and largest of the hydro-electric installations of the Consumers Power Co. in Michigan.

Oil-Engine Industry Is Picking Up

IN KEEPING with the general trend of business, the oil-engine industry during the early part of 1921 experienced a considerable depression. This period of inactivity has been passed, and during the latter part of the year a fairly large volume of business was booked, making the total year's sales approximately 50,000 hp. While this volume of sales during a year of general depression proves the stability of the oil engine and its predominant position in the isolated power-plant field, there is no doubt that a far larger horsepower would have been sold if several industries in which the oil engine is supreme had not suffered an almost total loss of activity. The copper-mining field in the past has

absorbed a large Diesel horsepower, but in 1921 no large orders for engines were placed by the mines. Likewise the oil-pipe lines did not show signs of purchasing intention until the middle of the year. In recent months the opening of the Mexia, Texas, oil fields and other developments have produced orders for approximately 6,000 hp. The central-station industry, especially the municipal plants, has taken a number of engines of small and medium powers. Other lines, including the textile trade, have placed an occasional order. The Navy has been responsible for a considerable portion of the year's orders.

In the merchant marine, contrary to the general expectation, no general trend toward the adoption of the Diesel engine is apparent. During the year most of the larger vessels ordered were for the Mexican tank trade, and shipbuilders and architects are by no means convinced that steam power using the Mexican boiler oil is more expensive to operate than the Diesel if a higher-grade fuel oil is used with the latter.

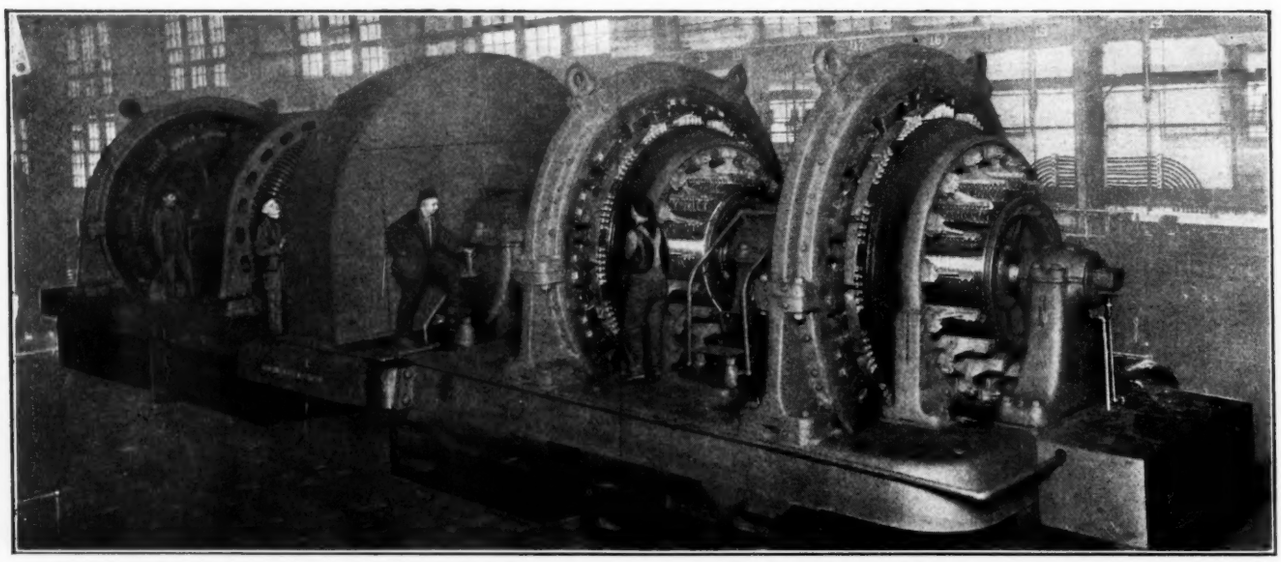
On the other hand, a great many small vessels have purchased semi-Diesel engines on the ground that for harbor and coastwise work the lower first cost of this type of engine more than offsets the increased fuel costs.

The sales of semi-Diesel engines did not keep pace with the sales of previous years. Since the large proportion of these engines go into small plants, which reacted very quickly to the general industrial depression, semi-Diesel orders showed a marked slump.

During the year the most striking plants to be installed were in the copper industry, where four 2,000-hp. two-cycle Diesel engines were installed. From the economic point of view the completion of the Diesel-engine station of the Chicago Drainage Commission is most interesting. This plant, which contains four 750-hp. Diesels, will furnish power to the Chicago Park system, and since coal is comparatively cheap in Chicago the cost of operation of this plant compared with the costs of steam plants in the same district will be studied by engineers with a deal of interest.

The coming year promises to see a decided drift toward the Diesel engine in the central-station field where the demand will be for units of 1,000 hp. and under. The revival of copper mining and the replacing of existing steam plants along several oil-pipe lines will afford a large volume of business to the Diesel manufacturer. High coal prices in some localities have caused many industrial plants to give more attention to the Diesel engine and its possibilities.

In the marine field, overcrowded as it is with vessels looking for a cargo, it is hardly to be expected to see any great number of new vessels launched, and most of these will go into lines of trade where the general feeling is that the first cost of the Diesel installation and the time at sea are the obstacles that cannot be overcome by the lowered operating costs. On the other hand, there will be many semi-Diesels of small powers installed in tugboats, fishing boats and coastwise vessels.



GENERAL ELECTRIC FLYWHEEL MOTOR GENERATOR, CONSISTING OF THREE 2,700-KW. 600-VOLT GENERATORS, A 50-TON FLYWHEEL AND A 5,000-HP. 4,000-VOLT INDUCTION MOTOR, FOR SUPPLYING POWER TO A 7,000-HP. BLOOMING-MILL MOTOR

In Diesel-engine circles there is a general feeling that 2,000 hp. per unit will remain as the engine of maximum capacity for some time, and the effort of engineers will be directed toward the perfecting of present designs rather than in increasing the range of powers.

The solid-injection oil engine has received much attention and is now built by a number of manufacturers, some of whom advocate the air-injection Diesel for sizes over 300 hp., confining the solid-injection engine to units of less than this power.

As a whole the oil-engine industry is in a better position than that of any of its prime-mover competitors, and a total 1922 sale of over 75,000 hp. is to be expected and will be secured if the present activity is sustained.

The gas-engine manufacturers have not been so fortunate as the oil-engine builders. The greater number of gas engines of other than farm sizes go into the oil fields, which absorb in good years about 7,000 engines averaging 25 hp. each. This volume of sales was by no means secured in 1921, but awakened oil-field activity should help to bring the business back to normal.

In small farm units the decrease in sales was most marked as a result of the tremendous decrease in buying

ability of the farmers. A number of factories that were closed down for several months are now running with a fair output. Upon studying the trend of the internal-combustion industry, one is impressed with the fact that the liquid-fuel burning engine is rapidly supplementing the gas engine even in fields that have seemed to be particularly adapted to the gas engine.

Refrigeration Shows Interest in Compound Compressors

REFRIGERATION is one of the essential industries which suffers less from general depression than do most lines of trade. During 1921 a large number of new plants and additions to existing plants were built, the major part being cold-storage and not ice-making plants.

The interest displayed during the last few years in the compound compressor was repeated in 1921. A number of such machines of capacities up to 500 tons were installed; and the tests published prove the superiority of the compound compressor over the single-cylinder unit, especially in plants carrying more than one suction pressure.

The choice of a prime mover has always been a vital factor in the refrigerating field. The synchronous motor is being installed in the majority of new plants where central-station service is available. The drift toward the motor drive has been largely due to central stations making a refrigeration-plant rate much lower than industrial rates.

The competitor of the electric motor is the unaflow and poppet four-valve steam engine. The unaflow has been placed in a number of important refrigerating plants and has shown a cost of power per ton better than the cost of electric power.

Safety regulations and the formation of a standard code has continued to occupy the attention of engineers. New tables covering the properties of saturated ammonia were made public by the United States Bureau of Standards. The Bureau, assisted by a fund provided by the American Society of Refrigerating Engineers, is working on tables of superheat; these, however, will not be issued for some time.

Better Metering Facilities

To ascertain operating conditions and to be able to compare past with present performance, accurate meters in sufficient number to give full data are secondary only to the actual equipment doing the work. With fuel still relatively high in price, it is gratifying to report marked activity in the meter field. Meters have been improved in accuracy, new meters for various purposes have been brought out, and new combinations made of previous methods of measurement. For example, air-flow and temperature pens have been added to the steam-flow meter, a combined CO_2 recorder and steam-flow meter is available, and another new device is a recorder of both combustible gases and CO_2.

There has been considerable improvement in combustion control, and a number of new regulators have appeared during the year, not only for individual damper control, but for master control of the plant, with separate regulators to care for individual fuel-bed conditions. A simple CO_2 indicator requiring no liquid reagent has been designed to give continuous readings. Installation of an induction regulator to maintain constant voltage and the addition of more contact points in the body of the electric steam-flow meter have increased the accuracy. There is a new instrument to record the ashpit loss in a chain-grate stoker. A piece of glass tubing with a bulb on the end has been calibrated to determine the concentration of boiler-feed water. A contamination meter detects electrically the presence of salts or acids in condensate or boiler-feed water, indicating leakage in the condenser. In draft gages a three-pointer instrument is the latest; there is a new vibration indicator for use on any external portion of a turbo-generator set, and a new coal meter measures the flow of the coal in the down-spout to the stoker, which has shown an accuracy within 2½ per cent.

A worthy achievement in the water-power field is the recent development to a commercial stage of an ingenious method of measuring the flow of water in-penstocks, by N. R. Gibson, hydraulic engineer of the Niagara Falls Power Co.

This new method operates on the principle that when the flow through a pipe line is stopped or partly arrested, the stored energy in the water due to the moving mass is dissipated in the form of pressure waves which are transmitted along the column of water in the pipe, similar to sound waves. Mr. Gibson has provided a means of measuring and photographing these waves so as to obtain a permanent record, from which the flow of water may be accurately determined.

High Voltage Center of Interest in Electrical Development

ELECTRIC-power equipment is becoming so well standardized for low and medium voltage and units have reached such large capacities in past years, that radical changes could hardly be expected. During 1920 a feature that attracted as much attention as any was the announcement that one manufacturing company was experimenting with 1,000,000 volts. Another company has built a 1,000,000-volt transformer. This company reports that with the completion of its new laboratory, 1,500,000 volts will be available for experimental purposes. Of course this voltage can be considered only as experimental and not commercial.

What is of greater commercial importance was the completion of 220,000-volt transformers and switching equipment for the Southern California Edison Co. These transformers are single-phase units of 8,333-kva. capacity. Three of these units will be connected delta on the low-voltage side and star on the high-voltage side to form a 25,000-kva. bank. The high-tension bushings on these transformers were tested at 485,000 volts for one minute. A transformer of unusual interest is one designed to deliver 50,000 amperes continuously at 20 volts and has delivered a maximum of 72,000 amperes. This unit is used for experimental welding.

Another company reports manufacturing seven 16,667-kva. 222,000-volt transformers for the Pacific Gas and Electric Co., three additional 23,600-kva. transformers for the Colfax Station of the Duquesne Light Co., and fifteen 15,000-kva. 25-cycle transformers for the Queenston development of the Ontario Hydro-Electric Power Commission. These latter units are claimed to be physically the largest single-phase transformers ever built. Another company reports a contract for eight 10,000-kva. transformers from the Pacific Gas and Electric Co.

Other notable high-voltage equipment are two 15,000-kva. and one 5,000-kva. synchronous condensers, wound for 15,000 to 18,000 volts, for the Southern California

Edison Co. This company has also installed two 10,000-kva. and the Pacific Gas and Electric Co. two 20,000-kva. synchronous condensers. The company that built these units also reports the construction of three 15,000-kva. and four 8,000-kva. machines for the Medi Railway electrification in France.

In the field of generating units the sizes as laid down in the previous year still hold the field, as indicated by the prime movers discussed in another part of this review. There is, however, under construction a 41,000-hp. unit for the Shawinigan Water and Power Co., which, although considerably under the 55,000-hp. Queenston units in power capacity, exceeds them in physical dimensions. As an indication of the tendency in large-sized units one company reports as built or on order 450,000 kva. of turbo-generators of 25,000-kva. capacity and over, also 460,000 kva. of waterwheel generators of 12,000-kva. capacity and above, during 1921.

A feature that will undoubtedly have far-reaching effects in the operation of turbo-generation is the recirculating of the ventilating air. A system of this kind has been put in operation on the generators in the South Meadow Station of the Hartford Electric Light Co. In this system, after the air passes through the generator it goes through a water spray, is cooled and recirculated. In this way dirt is practically eliminated from the windings, and it also makes possible the effective use of an extinguishing gas should a fire start in the machine.

The bringing to the outside of the generator both leads of each phase of the winding and connecting in a differential relay protection, so as to disconnect the machine in case of internal trouble, continues to be in favor. Also, grounding the neutral of large generators through a resistance has become practically standard practice in new installations.

For driving power-plant auxiliaries, the tendency is toward the electric drive at a voltage of 2,300, even for units down to 25 hp., except on cranes and coal towers, where 220 volts is used.

Tests on switching equipment during the last year has demonstrated that recent designs of oil switches are capable of standing up under the strains of short-circuits on large power systems. In one case an oil switch satisfactorily ruptured 12 successive short-circuits in close sequence on a 13,200-volt system. The short-circuit kilovolt-amperes in each case were approximately 600,000. Oil switches have been designed having a rupturing ability of 66,000 arc amperes at 13,200 volts. High-speed circuit breakers have been designed for direct current which have completely opened the circuit in 0.008 second after the short-circuit started.

Great engineering progress has been made in the field of automatic-substation control, resulting in the eliminating of attendants. These substations, originally designed for railway purposes, have been adopted for such services as steel mills, mines, office buildings and industries. One company reports supplying seven of these stations during 1921 in addition to several cases where automatic control was applied to existing installations. A number of small automatic hydro-electric plants have also been put into service.

The proposed Kansas City (Mo.) Automatic Edison System indicates the trend of development in automatic control of rotary converters and motor-generators. The entire Edison system of the city will be controlled from a series of five automatic substations, each containing two synchronous converters operating independently. These substations will be fed from a central steam-generating plant, through a radial network of feeders. The present capacity of the generating station is 60,000 kw., but its ultimate capacity is expected to be more than 150,000 kw.

Two steel-mill installations during the year, remarkable for their size, are an 8,000-hp. reversing motor for the Lackawanna Steel Co.'s rail mill and a three-unit generator and motor used on a 40-in. reversing blooming mill at the Tata Iron and Steel Co., Jamshedpur, India. The Lackawanna motor has the largest horsepower rating of any electric reversing drive in the world. The Tata motor is rated at 7,000 hp. at 55 to 120 r.p.m. and a maximum momentary capacity of 22,000 hp. at 50 r.p.m. Power is supplied by a flywheel motor-generator set consisting of three 2,700-kw. generators and one 50-ton flywheel, all driven by a direct-connected 5,000-hp. induction motor.

In the application of small-sized motors to industrial machinery that requires high-speed motors, the development of an induction frequency-changer set, consisting of a two-unit motor-generator outfit that generates power at frequencies as high as 300 cycles, which supplies power to induction motors ranging in speed from 3,600 to 12,000 r.p.m. is a development of note.

An interesting motor installation has been made for high-pressure fire-pumping service in Boston. Two 750-hp., 1,000 r.p.m. direct-current motors are used. Automatic control is provided so that the equipment can be controlled from one point, and motor-operated valves are installed, which open automatically as the pumps are started.

For use in industrial plants a valuable development has been the introduction of automatic starters for synchronous motors. These motors can now be started as easily as induction motors, so that the only starting operation required by the attendant is the operation of a push button.

The feasibility of arc-welding alloy steels has been demonstrated during the last year. With adequate mechanical and heat treatment, tensile strength of welds of the order of 130,000 lb. per sq.in. have been secured. The forgeability of arc-deposited metal has been demonstrated, as well as the resistance of the forged metal to fatigue stresses, thereby furthering the field of application for this process.

Engineering Societies Active

IN ENGINEERING-society circles the chief event was the survey of industrial wastes, outlined by Herbert Hoover as chairman and carried out by American Engineering Council, the governing body of the Federated American Engineering Societies. It was planned to investigate ten leading industries, but for various reasons the work was limited to the following six: Building trades, men's ready-made clothing, boot and shoe, printing, metal trades and textiles. The final report of the Council has been issued recently in book form. An unfortunate event was the resignation of Mr. Hoover as chairman early in the year, made necessary by his appointment to the Portfolio of Commerce in the Cabinet, but later the Council was fortunate in securing a worthy successor in Mortimer E. Cooley, Dean of the Colleges of Engineering and Architecture of the University of Michigan. Other things in which the Council has been interested are a unified employment service

for engineers, the remedy of conditions in the Patent Office, classification and compensation of engineers, the establishment of a national department of public works, types of Government contracts, New York State government reorganization and numerous bills pending in Congress. There are now twenty-nine member societies, representing over 45,000 engineers. For the next few months the chief objective of the Federation will be to solidify its membership.

The United Engineering Society, comprising the four national societies of the mechanical, electrical, civil and mining engineers, stepped into the limelight by awarding the unique distinction of honorary membership in all four societies to Marshal Foch just at the end of his visit in this country.

The American Society of Mechanical Engineers made ready for publication its Elevator Safety Code, approved finally during the early part of the year, the Code for Miniature Boilers and the Code on Boilers of Locomotives. The revised power-test codes on General Instruction and Reciprocating Steam Engines were adopted, and progress is reported on the codes for Evaporating Apparatus and Air Tanks and Pressure Vessels. Among other things the society is conducting an extensive research into the properties of steam with a view to the preparation of new steam tables. A new constitution for the society is also under consideration.

During the year the new American Society of Lubrication Engineers held its first annual convention. A new society, having for its object the collection and coordination of data on friction-drive engineering, was organized, and the several manufacturers of heavy-oil engines effected a temporary organization to advance the interests of this type of prime mover, with the intention of completing the permanent organization at a later date. Another association born with the year is the Personnel Research Federation, organized under the auspices of the National Research Council and Engineering Foundation. Its purposes are to co-ordinate the activities of the 250 scientific, engineering, labor, management and educational bodies in the United States that are studying personnel problems, to collect personnel research information and to encourage such research through individuals and organizations.

International standardization was advanced in a recent conference held in London by the secretaries of the national standardizing bodies of Belgium, Canada, Great Britain, Holland, Norway, Switzerland and the United States.

One of the incidents of the year, which may grow into a great service to the hydraulic field, was an offer to the Engineering Foundation, if supported by financial assistance, by one of the largest hydraulic-power companies in America, to make its valuable facilities available for research work. An eminent hydraulic engineer has offered his services in conducting the work. To take advantage of the opportunity, a special fund of not less than $25,000 a year, for several years, will be needed.

The American Society of Heating and Ventilating Engineers is continuing work of great value to the field in its research laboratory at Pittsburgh. F. P. Anderson, Dean of the College of Engineering, University of Kentucky, has been made the new director of the laboratory to succeed L. A. Scipio, Dean of Robert College, Constantinople, who had been an associate and temporarily had been carrying on the work instituted by the late John R. Allen.

The Honor Roll for 1921

THE review would be incomplete without brief mention of those honored for the merit of their work and the selections made of representative engineers to head their respective associations. At the midwinter convention of the American Institute of Electrical Engineers, M. I. Pupin was presented with the Edison medal "for work in mathematical physics and its application to the electrical transmission of intelligence." The John Fritz medal for 1921 was awarded to Sir Robert Hadfield, of England. A delegation of American engineers, representative of the four founder societies, made the award in England before the British Institution of Engineers. Anticipating the 1922 award to Eugene Schneider, of France, the board of award broadened its plan and carried out similar ceremonies in Paris. The former recipient had taken a prominent part in the development of the steel industry, and the latter award was made for achievement in metallurgy of iron and steel and the development of ordnance.

J. M. Spitzglass, of the Republic Flow Meters Company, was honored with the Longstreth medal of merit by the Franklin Institute, "in consideration of the novelty of recording electrically the flow of liquids in pipes and the mechanical simplicity and excellence of this measuring apparatus." The Franklin medal was awarded to M. Jusserand, the French Ambassador, and to Frank J. Sprague. Honorary membership was included with the awards, and a similar courtesy was extended to General John J. Pershing.

By the American Society of Mechanical Engineers honorary membership was awarded to Henry R. Towne and Nathaniel G. Herreshoff. Mr. Towne, who is directing head of the Yale & Towne Manufacturing Co., has been a pioneer in appreciating the broadening function of the engineer and will be long remembered for his contributions on this subject. While Mr. Herreshoff's genius has meant the retention of "America's" Cup in this country, his great claim for recognition has been in the development of the science of naval architecture.

Word comes from across the water that a fund of £11,407 in honor of James Watt has been raised in England. Previous reviews have referred to this movement. It is proposed to give £5,000 to Birmingham University to establish a Chair of Research in Mechanical Science, and later to accumulate a fund large enough to provide a memorial building to serve as a meeting place and library for technical societies.

Men who have been honored by selection to lead the respective engineering organizations closely related to the power field are: Dean M. E. Cooley, American Engineering Council of the Federated American Engineering Societies; Dexter S. Kimball, American Society of Mechanical Engineers; William McClellan, American Institute of Electrical Engineers; M. R. Bump, National Electric Light Association; W. S. Hall, Association of Iron and Steel Electrical Engineers; A. G. Pratt, American Boiler Manufacturers' Association; Maxwell Alpern, Stoker Manufacturers' Association; Richard W. Parry, National Association of Stationary Engineers; George T. Crumm, American Order of Steam Engineers; C. L. Riley, American Society of Heating and Ventilating Engineers; J. H. Walker, National District Heating Association; Harry Sloan, American Society of Refrigerating Engineers; John Jung, National Association of Practical Refrigerating Engineers; Joseph M. Lonergan, Smoke Prevention Association.

What the Indicator Will Tell

Here is something that every operating engineer should read. This article, which is the first of a series, explains the indicator and the information to be secured through an indicator diagram taken from an engine.

IF A sheet of cross-section paper were laid off so that horizontal measurements represented to some scale the distance traveled by the piston of an engine from the beginning of the stroke, and vertical measurements represented to scale the pressure existing within the cylinder at the various points in the stroke, a diagram similar to Fig. 1 would be developed.

Since the pressures are measured from zero absolute, this zero absolute pressure line *OX* should be drawn on the paper. Likewise it is in most cases desirable to

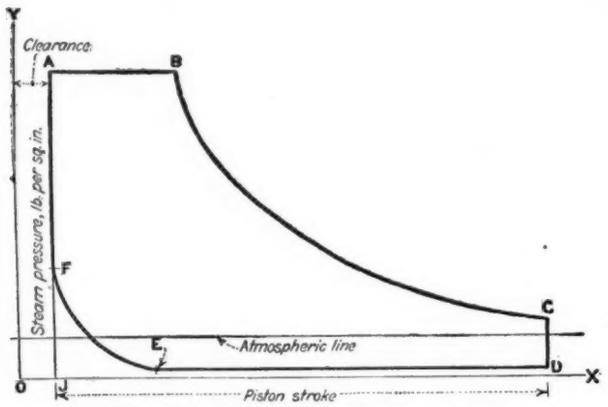


FIG. 1. THE STEAM-ENGINE PRESSURE-STROKE DIAGRAM

have the zero volume line *OY*. Horizontal distances on the diagram actually represent inches of piston stroke, but when multiplied by the area of the piston likewise represent the volumes swept out by the piston, and consequently are often termed the stroke volumes. At the beginning of the piston stroke there is a clearance space in the cylinder and steam passages which must be filled with steam before the piston moves. So the pressure-stroke of the diagram is set at a distance from the line *OY* proportional to this clearance volume, enabling the actual volume of steam in the cylinder at any point in the piston stroke to be measured. As a matter of comparison the line showing the atmospheric pressure (0 gage) is also drawn on the diagram.

As the diagram shows, the steam is admitted at an absolute pressure (gage + 14.7) as indicated by the distance *AJ* from the zero-pressure line *OX*, and as the piston moves forward steam continues to pour into the increasing cylinder volume until at *B* the steam supply is cut off, and the steam trapped in the cylinder expands behind the piston at a falling pressure, as indicated by the curve *BC*. At *C* the exhaust passage is opened, the spent steam flows into the condenser, where the pressure is considerably lower, say 2 lb. absolute (—13.7 gage), or 26 in. of vacuum, and the cylinder pressure drops from that represented by *C* to that represented by *D*. On the reversal of the piston the steam remaining in the cylinder is pushed out by the moving piston, the pressure remaining at the condenser pressure *D* as indicated by the horizontal line *DE*. At *E* the exhaust passage is closed and the steam left in the cylinder is compressed by the advancing piston to some pressure, which at the end of the stroke may be *F*. The steam valve now opens, live steam flows in and the cylinder pressure rises to the value represented by *A*. The continued rotation of the crank and the reversal of the piston travel starts the engine on a new cycle of *steam admission, expansion, release, exhaust and compression.* The several events on the diagram may be listed as follows:

Admission Line—Steam is admitted into the clearance space, raising the pressure to that of the boiler or steam chest.

Steam Line—Steam flows into the cylinder, exerting a uniform pressure on the moving piston.

Expansion Line—Cutoff occurs and the steam expands behind the moving piston, increasing in volume and decreasing in pressure.

Release—The exhaust passage is opened and the steam in the cylinder escapes until its pressure is equalized with that of the exhaust line.

Exhaust Line—The moving piston on the return stroke forces the steam remaining in the cylinder out through the exhaust port.

Compression—The communication with the exhaust passage is closed, and the steam remaining in the cylinder is compressed by the piston, decreasing in volume and increasing in pressure.

If we could have such a diagram, giving the pressure in the cylinder at every point on the forward and backward strokes, we could tell how promptly and to what extent the pressure was realized in the cylinder; how well the pressure was sustained while the engine was taking steam; at what point in the stroke cutoff occurred and whether the valve cut the steam off sharply or dragged; whether the expansion proceeded as it should

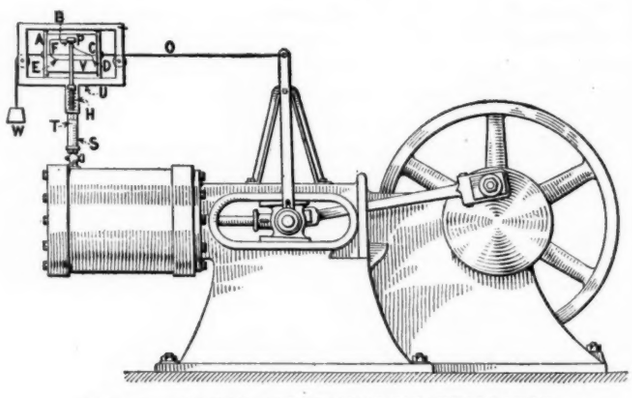


FIG. 2. WATTS STEAM-ENGINE INDICATOR

or was materially affected by leakage or by the transfer of heat to and from the cylinder walls; at what point in the stroke the exhaust valve opened and whether the release of the expanded steam was prompt and effective. In addition it would be possible to secure information on the question of—

How much back pressure the engine was working

against; whether the exhaust passages and main were ample and free; what vacuum was realized in the cylinder; at what point in the return stroke the exhaust valve closed for compression; how high the compression was carried and whether it proceeded as it should or was lost by leaking exhaust valve or piston or accelerated by a leaky inlet valve.

By measuring the difference between the average forward and backward pressures, the work done per stroke can be determined and the horsepower of the engine computed.

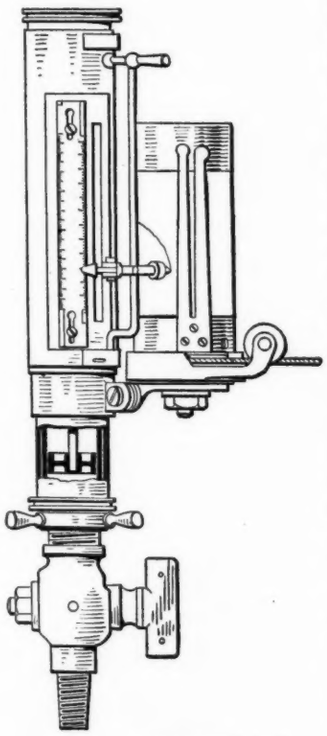


FIG. 3. McNAUGHTON'S INDICATOR

By measuring from the diagram the pressure of the steam at some point in the stroke after cutoff and multiplying the volume of the cylinder up to that point by the weight of dry-saturated steam of the measured pressure per unit of volume the weight of steam accounted for at that point per stroke or per hour can be computed. This is likely to be considerably less than the steam actually taken by the engine, as some of the steam admitted will probably have condensed, but the difference between the steam thus accounted for and that actually furnished the engine will throw light upon the extent and manner of cylinder condensation.

Diagrams from internal-combustion engines will show the freedom of the intake, the work lost by suction, the extent and perfection of the compression, the point at which ignition takes place, the pressure realized by combustion or explosion and the rapidity of the process, and the manner in which the heated gases expand; also the power that the engine is developing, as well as defects in the mechanical details of the engine.

As applied to the liquid cylinders of pumps, it shows the pressure existing in the cylinder during the suction and delivery strokes, the adequacy and action of the inlet and discharge valves and enables one to compute the amount of work done in handling the liquid.

On compressor cylinders, air and ammonia, it shows the amount and distribution of the pressure in the cylinder during the suction stroke, the effect of the re-expansion of the unexpelled contents of the preceding stroke, the increase of pressure during compression, the degree to which compression is carried, the point in the stroke at which the discharge valve opens and the manner in which and pressure at which the contents are discharged, the action of inlet and discharge valves, excessive leakage, and gives the data for computing the power consumed.

As applied to the steam chest or the steam main near the engine, it gives the variation of pressure at these points during the stroke and enables one to judge of the adequacy of pipes, valves and passages and to locate the causes of undue loss of pressure between the boiler and the piston.

By computing the pressure necessary to overcome the inertia and momentum of the reciprocating parts of an engine, subtracting that required to get them into motion from the pressures shown by the indicator while their motion is being accelerated and adding the pressures exerted by the moving parts upon the crankpin in its effort to bring them to rest to the pressures shown by the indicator during the period of retardation, a diagram can be constructed that will show the turning effort upon the crankpin at each point in the stroke or revolution and that will settle many problems of regulation and noisy running.

The diagram as drawn by the indicator can be transferred to the temperature-entropy plane, revealing the causes of the failure of the engine to convert more of the heat with which it was furnished into useful work.

It is the purpose of this series of articles to describe the different forms of indicator available, to give directions for testing their accuracy, for attaching them to the engine, to describe different methods of and devices for reducing the motion of the crosshead to that required for the diagram, to tell how to take and interpret diagrams, to compute the horsepower and steam accounted for, to set the valves of various types of engine pumps and compressors by its assistance, how to combine the diagrams from compound and other multi-stage engines, how to construct the crank-effort diagram from the indicator diagram and how to transfer the indicator diagram to the temporary-entropy plane. This will all be done so simply that anyone can follow it and will be

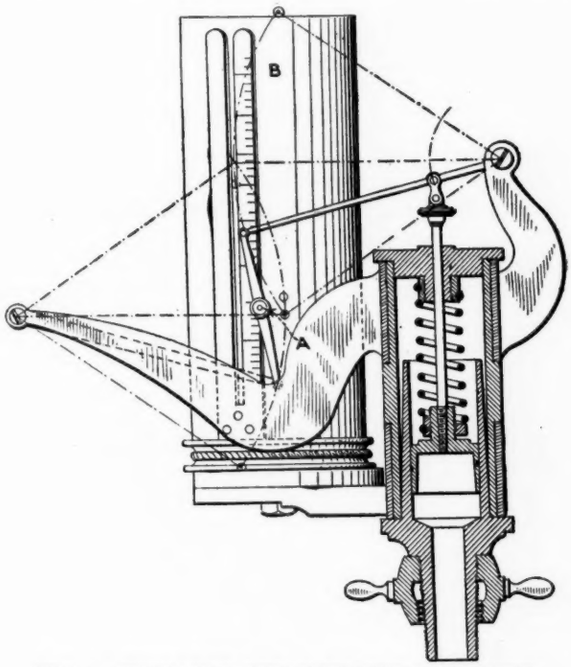


FIG. 4. RICHARDS STEAM-ENGINE INDICATOR

accompanied with tables and charts that will reduce the computations to a minimum.

James Watt, who is regarded as the originator of the practical steam engine, set about to construct some contrivance to obtain such a diagram of the cylinder events. The result of his labor was the Watt steam-engine indicator shown in Fig. 2. Here the indicator is attached to the cylinder and the diagram board *V* which slides

in the frame U is connected by a cord O to rocker arm attached to the crosshead; the weight W holds the cord taut. Since the indicator cylinder S, which contains a piston T and a spring H, is connected to the steam cylinder, the steam exerts the same pressure per square inch on the piston T as it exerts on the engine piston and overcomes the spring resistance. The pencil P at the end of the indicator piston rod then rises and falls with the changes in pressure within the engine cylinder.

As all know who have used spring balances, the heavier the weight loaded on the scale pan the greater is the movement of the spring, and the scale reading, although marked in pounds, actually represents the movement of the spring. The motion of the piston T is transmitted to the pencil P. If the engine piston is at the end of the stroke and boiler pressure is turned on, the pencil will be at the point A. As the piston moves on, the stroke the board travels with the crosshead and the pencil makes a line AB, where cutoff takes place, whereupon the steam expands along BC. The opening of the exhaust valve reduces the pressure on the piston, and the pencil moves to D. On the return stroke the weight holds the cords tight and the line DE is made by the pencil. At E compression takes place and the line EF is made. The atmospheric line is made by cutting off the opening to the cylinder and allowing the indicator cylinder to be open to the atmosphere, whereupon the pressure on the bottom of the indicator piston being that due to the atmosphere, a straight line is obtained at a distance from the zero pressure line proportional to the pressure of the atmosphere. The reader will observe that at any point in the piston stroke the pressure within the engine cylinder is the same as that in the indicator cylinder, and the pencil position is proportional to this pressure. The diagram so secured is then a representation to scale of the events in the engine cylinder.

High-Speed Indicators

While this indicator, with all its faults of great weight, etc., was fairly satisfactory for engines making 30 strokes or less per minute, it was of little use when engine speeds were increased, since the length of spring and weight of the piston were such that at the instant steam was admitted to the engine, the inertia of the indicator parts tended to cause the indicator piston to travel higher than it should. The Watt indicator was improved and developed with the idea of reducing the inertia and errors; the first step was to convert the diagram board into a drum. One of these early indicators, that of McNaught, is shown in Fig. 3, where the paper is placed on a light drum which is rotated by a cord from the engine crosshead. The indicator did not become a serviceable instrument until Charles B. Richards, of Providence, R. I., brought out the Richards indicator, Fig. 4. This instrument was fitted with a strong spring giving a very small travel to the piston, which eliminated the inertia of the long springs used before.

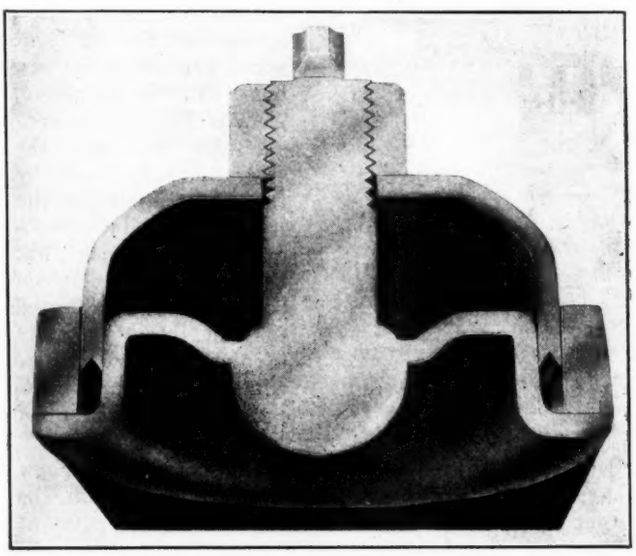
The Richards indicator consisted of a brass cylinder with a connection to the engine cylinder. A very light piston was inserted in the indicator cylinder, being provided with a heavy spring and a light piston rod which was connected by a linkage to the parallel motion. The parallel motion was designed to give an almost straight line vertical motion to the point A, thus eliminating distortions of the pencil tracing. The indicator diagram paper was wrapped around the barrel B, which contained a coil spring to bring the drum back in place of the weight used by Watt. The pencil motion multiplied the short travel of the indicator piston to give a fairly large diagram. This gave a tremendous impetus to the interest in the steam engine, and many engineers began to study the effect of valve setting and design.

Modern indicators are not expensive, especially in view of the fine machine work embodied in their manufacture. The indicator is a tool that every engineer, whether he be in charge of steam engines, air compressors, oil and gas engines or refrigerating compressors, should possess. No greater improvement in power plant efficiency can be secured than by the correction of faults revealed by the indicator.

Key Special Handhole Plate

A new design of handhole plate, known as the Key Special, is suitable for all equipment necessitating handhole plates or screw plugs.

In order to make use of this plate, the handholes should be tapered 3 deg. on the side from the outside in. This makes it possible to enter the plate through its own hole. The closure ring is then inserted and is held in position between the 3-deg. taper on the handhole plate and approximately a 10-deg taper in the closure plate; hence the joint is made in the hole. To remove, loosen up on the nut three or four turns and then strike the end of the stud a light tap with the hammer and jar the closure plate loose; in other words, drive it a little back in the hole, then take the nut off and the closure plate is easily removed. These plates can be detached in about 20 seconds and reinstalled in about 25 seconds. They are manufactured by the Key Boiler Equipment Co., East St. Louis, Ill.



SECTION THROUGH HANDHOLE PLATE

The closure plate is of pressed steel five gage in thickness. The stud or bolt is driven in cold under 450 tons pressure, making a leakproof joint. The closure rings are generally made of pressed steel, but for some special purposes they are made of brass. The end of the stud is provided with an opening, through which a wire hook may be inserted to hold the plate and prevent it from falling into the interior of the boiler when in the act of removing it.

Lubrication—What Is Petroleum?

By W. F. OSBORNE*

Every engineer should be interested in lubrication. This article tells what petroleum is. In each issue of POWER *during 1922 will appear an article discussing some phase of lubrication. Keep these pages and so have a complete treatise on the subject.*

PETROLEUM, as it is found in the earth is mixed with a great many different substances. The constituents that make up the actual petroleum are carbon and hydrogen, all other elements being in the nature of adulterants or foreign compounds, which must be removed in the refining process.

The hydrogen and carbon are in the form of compounds called hydrocarbons, which contain the same two elements only, although differing in the percentage of each element present and also in the way in which the atoms of the elements are combined together within the hydrocarbon molecule. The molecule structure of a compound may have one of several forms, and all compounds having the same general forms have similar properties. The most familiar of these classifications are the paraffin, naphthene, and aromatic series.

The first series, the paraffin, consists of molecules containing two more than twice as many hydrogen atoms as carbon atoms, the formula C_nH_{2n+2}. The number of these groups of atoms combined into a single molecule determines the individual hydrocarbons of the series.

The naphthene series consists of molecules containing twice as many hydrogen as carbon atoms in each molecule, and the compounds have the general formula C_nH_{2n}. These compounds are found in many of the Southern and California crudes and give to these crudes the frequently used name of naphthene crudes. Another name sometimes given to these crudes is "asphaltic," which does not necessarily mean the same thing at all. The asphaltic crudes are so named because they contain asphalt, a mixture of the heavier hydrocarbons and oxidized hydrocarbons.

The aromatic series consists of the familiar compounds normally obtained by the distillation of coal tar, such as benzene, toluene, xylene, etc. Benzene, which is typical of the series, has the formula C_6H_6. All of the members of the series have as many hydrogen atoms as carbon atoms and have the general form of C_nH_n. They are found in certain crudes in small quantities.

Each individual hydrocarbon of any of these series has distinct physical properties as shown by their gravities, boiling points, vapor pressures, viscosities, etc. When mixed together, as they are found in petroleum, they are probably closely associated to a more or less extent, and as they are all soluble in each other, the petroleum mixture frequently has properties quite different from what might be expected of the several distinct hydrocarbons which it contains. In other words, it is difficult to foretell just what properties a mixture of a number of hydrocarbons will possess, and it is equally difficult to determine from the properties of a crude, just what hydrocarbons can be separated.

The hydrocarbons are difficult to separate, and when an attempt is made to separate one compound, other hydrocarbons, both lighter and heavier, also separate from the crude. This means that all commercial petroleum products are mixtures of a number of hydrocarbons, some lighter and some heavier than the average. The table shows the principal hydrocarbons in some of the commercial products and also indicates how they overlap one another. Obviously, the method of refining determines to a large extent the constituents of any commercial product, such as lubricating oil.

For instance, a lubricating oil of the paraffin series might contain a small percentage of $C_{14}H_{30}$, a larger per cent of $C_{16}H_{34}$, a still larger amount of $C_{17}H_{36}$, a small amount of $C_{22}H_{46}$, and a much smaller quantity of $C_{24}H_{50}$, with a proportional amount of the various compounds ranging between those mentioned. These varying percentages of light and heavy products account for the variable flash and fire points obtained.

PARAFFIN COMPOUNDS

Classification		Formula		Boiling Point Deg. F.
Methane	Gas	CH_4		320
Ethane	Gas	C_2H_6		—200
Propane	Gas	C_3H_8		—11
Butane	Gas	C_4H_{10}		†33
Pentane	Gasoline	C_5H_{12}		97
Hexane	Gasoline	C_6H_{14}		156
Heptane	Gasoline	C_7H_{16}		191
Octane	Gasoline	C_8H_{18}		258
Nonane	Gasoline	C_9H_{20}		277
Decane	Light Lubricating Oil	$C_{10}H_{22}$	Kerosene	316
Endecane	Light Lubricating Oil	$C_{11}H_{24}$	Kerosene	360
Dodecane	Light Lubricating Oil	$C_{12}H_{26}$	Kerosene	378
Tridecane	Light Lubricating Oil	$C_{13}H_{28}$	Kerosene	420
Tetradecane	Light Lubricating Oil	$C_{14}H_{30}$	Kerosene	460
Pentadecane	Light Lubricating Oil	$C_{15}H_{32}$	Kerosene	49[illegible]
Hexodecane	Light Lubricating Oil	$C_{16}H_{34}$	Kerosene	536
Heptodecane	Light Lubricating Oil	$C_{17}H_{36}$	Kerosene	...
Octodecane	Light Lubricating Oil	$C_{18}H_{38}$	Kerosene	...
Nonadecane	Light Lubricating Oil	$C_{19}H_{40}$	Heavy Lubricating Oil	...
Eicosane	Light Lubricating Oil	$C_{20}H_{42}$	Heavy Lubricating Oil	...
Encosane	Light Lubricating Oil	$C_{21}H_{44}$	Heavy Lubricating Oil	...
Docosane	Light Lubricating Oil	$C_{22}H_{46}$	Heavy Lubricating Oil	...
Tricosane	Light Lubricating Oil	$C_{23}H_{48}$	Heavy Lubricating Oil	...
Tetracosane	Wax	$C_{24}H_{50}$		...
Pentacosane	Wax	$C_{25}H_{52}$		...
Hexacosane	Wax	$C_{26}H_{54}$		...
Heptacosane	Wax	$C_{27}H_{56}$		...

The members of any series increase in specific gravity, boiling point and viscosity, as their molecular weight increases. For example, an oil of 0.90 specific gravity will ordinarily have a higher boiling point and greater viscosity than an oil of 0.88 specific gravity. Oils made from different crudes cannot be compared because the molecular structure of their individual members is different. A naphthene oil of 0.934 specific gravity will have a higher viscosity than a naphthene oil of 0.922 specific gravity, but it might not have a greater viscosity than a paraffin oil of 0.899 gravity. The same rule applies to all the other physical characteristics of lubricating oils. We must, then, compare paraffin oils with paraffin oils, and naphthene oils with naphthene oils.

Question. I have seen certain lubricating oils spoken of as "carbonless" or "non-carbon" oils. Would not these oils be very desirable for the lubrication of air compressors and Diesel engines?

Answer. Every oil contains carbon. If it did not contain carbon, the substance would not be oil, but would be something else. All petroleum lubricating oils contain from 85 to 86 per cent carbon, the remainder being hydrogen.

*Supervision Manufacturers Service, The Texas Co.

Reversing Rotation of Direct-Current Generator

By EUSTIS H. THOMPSON

WHEN a direct-current generator in good operation has its direction of rotation changed, it will be found that no voltage will be produced from the generator unless changes in connections are made. When the direction of rotation of a shunt-wound generator is reversed, interchange either the field or armature connections, but do not change both. If the brushes are shifted from neutral or if the brushes are run at an angle with the commutator, these conditions should be reversed.

Fig. 1 shows the usual connections for a shunt-wound generator. One shunt-field lead is usually connected to one side of the armature at the machine, while the other lead is taken to the switchboard and passed through the field rheostat, and from there to the other side of the armature circuit. The shunt field can be reversed by reversing the leads on the terminals F'_1 and F'_2 of the field windings themselves, by reversing the leads at their external ends F_1 and F_2. The armature connections can be reversed by reversing the leads of the brushes A'_1 and A'_2, reversing the leads at their outside terminals A_1 and A_2, or by shifting the brushes one pole space.

It is sometimes necessary to reverse the two main lines at the switch terminals E_1 and E_2. If the field wire is left as before, it will result in both sides of the field circuit being connected to one side of the line and the machine will not generate. In order to leave the field connected properly, lead G_2 connecting the rheostat to the switch must always be connected to the same terminal as E_2; that is, if the armature lead connecting to E_2 is connected to the right-hand terminal of the switch, G_2 must also connect to this terminal. Reversing the lines at the switch terminals E_1 and E_2 is sometimes necessary when it is desired to change the direction of the current supplied to the busbar without changing the polarity of the machine itself.

When the rotation of a prime mover has been reversed and the generator with the original connections will not "build up," the reason is that the small current that is now supplied to the shunt-field winding is in the opposite direction to that supplied before reversing the generator. If the circuit of the shunt field is opened, it will be noticed that a small voltage will register on the voltmeter. This is due to the residual magnetism in the polepieces, which remains in the field magnets similar to the magnetism of a permanent magnet. The voltage produced from the residual magnetism is usually about 5 per cent of the normal generator voltage. If the field circuit is closed, this voltage will drop almost to zero on account of the current circulating in the field winding tending to magnetize the polepieces opposite to the residual magnetism. After reversing the connection to the shunt field or armature, the current in the field winding will be in a direction to assist the residual magnetism and the voltage will build up to normal value unless changed by adjusting the field rheostat. If the machine is of the interpole type, the changes will be the same as for the non-interpole machine except for shifting the brushes described in the foregoing. In the interpole machine the interpole winding is usually included in the armature circuit, so that there will be only two armature and two shunt-field terminals, as in Fig. 2.

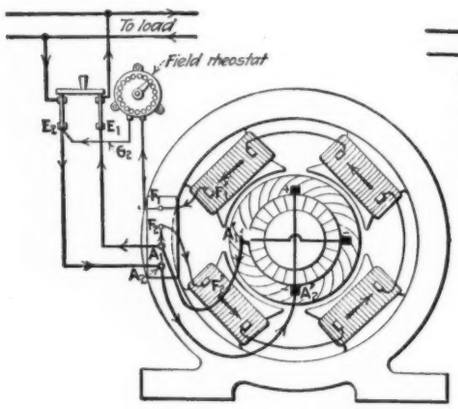


FIG. 1. SHUNT GENERATOR

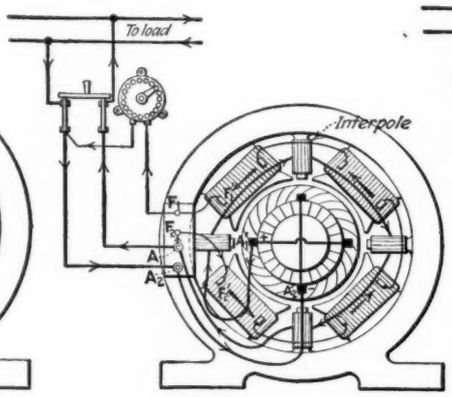


FIG. 2. SHUNT-INTERPOLE GENERATOR

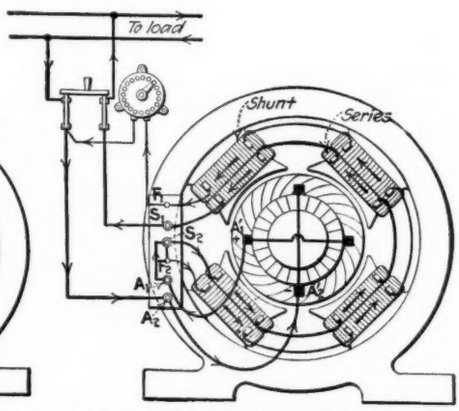


FIG. 3. COMPOUND GENERATOR

If the brushes are shifted over pole space, the interpole winding leads will have to be interchanged at A_1 and A'_1; that is, the interpole lead that connects to A'_1 brush is connected to terminal A_1 and the lead connecting to the terminal A_1 is connected to brush A'_1.

If the direction of rotation of a compound generator is reversed, the series-field leads must be reversed when the shunt field is reversed in order to retain proper polarity of the two windings. The series-field leads should not be reversed when the armature leads are reversed or when the brushes are shifted one pole space.

Fig. 3 shows the connections of a compound generator. If the direction of the machine is reversed, it will generally be found that the easiest way to get the proper connection for the machine to build up will be to reverse the armature connections A_1 and A_2 or shift the brushes one pole space. In either case the correct relation between the shunt- and series-field windings will not be interfered with. The polarity that the machine will have at its external terminals will depend upon whether the field or armature connections are interchanged to make the generator build up. If the field connections are interchanged, the polarity at the switch will be reversed, where if armature connections are interchanged the polarity will not be changed.

Uses Old Furnace Linings for Side-Wall Construction

By JOSEPH HARRINGTON

IT IS generally admitted by those having had experience with high-capacity furnace conditions that the limit to boiler ratings is the ability to maintain the brickwork. At combustion rates corresponding to anything over 200 per cent of rating, temperatures are necessarily developed that are close to the fusing point of first-quality firebrick, and in those installations having twin stokers under one boiler, the melting out of the center wall forms a definite limitation to the capacities that can be maintained. It has been repeatedly stated, and statements have been published to that effect, that the next move was up to the manufacturers of refractories and to the designers of furnaces.

In following up the situation at the plant of the Cleveland Electric Illuminating Co. where high ratings are developed with the stoker, this question of brickwork maintenance has, as usual, been of paramount importance. A furnace side wall, or arch, half burned through, has to be replaced, about one-half of the original brick material thrown away, and new material substituted therefor. It has even cost a considerable amount to get the old material carted away, so that there was double loss. It is to the credit of the ingenuity and foresight of J. A. Faulkner, boiler-room engineer at the Seventieth Street Station of the company, that there has been developed a method that promises to be one of the greatest steps in improving this situation.

> Monolithic furnace side walls of old firebrick ground and mixed with cement stand up better than the original brick, reduce radiation and air infiltration and permit operation of the boilers at much higher capacities.

The plan followed is to take the old furnace linings just as they come from the boiler wall, with the clinker and glass adhering thereto, and put them into a grinding pan similar to that used in the brick-making industry. Two large revolving rolls crush this material to a fairly uniform size, but not so fine that the nodules of silica are pulverized. It is necessary to stop short of fine pulverization, as this would destroy the characteristics necessary to firebrick and render it impossible to use the same material over and over again.

Each batch consists of about five-sixths of the old firebrick, and one-sixth of a high-grade, high-temperature cement. Little or no water is required, although the material is dampened sufficiently to make the resultant mass plastic enough to be workable. This material is so stiff that it can be handled in balls or masses and pounded in place with a mallet.

Experimentation has shown that the best method is to remove the 9-in. furnace lining, leaving in place, however, the occasional header row which projects into the 9-in. space and serves to tie the new material to the standing wall. A wooden form is erected, back of which is put the new material, which is pounded in place so as to form a continuous firm contact with the standing wall. It is the present practice to make this ganister facing 10-in. thick, and it has been laid up in some high-set Stirling furnaces all the way from a few inches above the grate surface to the top of the furnace. After being slowly dried out for two days with a wood fire, it is safe to get up steam.

To avoid the possibility of clinker formation and consequent destruction of the side walls by the slice bars occasionally used, three or four rows of carborundum brick are placed at the fuel-bed level. This gives a surface that largely resists the adhesion of clinker and prevents the slice bar from gouging out the material of the side walls, which is relatively much softer and more easily destroyed.

In attempting to solve the arch problem, Mr. Faulkner has also introduced a novelty that should be of interest. It had been their custom to use a flat-suspended arch, and they have suffered more or less from the spalling of these tile. With considerable originality Mr. Faulkner has worked out the plan of forming alternate rows extending from front to rear of the ganister previously described. He puts up a wooden form under the arch, puts in place every other row of arch tile, and then between these rows he pounds in the ganister to a thickness equal to the thickness of the tile. This avoids any cracks through the arch and prevents the hot gases from penetrating the cracks at the sides of the tile and causing the characteristic spalling. It also prevents the loss of gas through the arch whenever pressures are developed in the furnace.

The same result is noticed with the monolithic side-wall construction. There being no joints, there is no point where the flame can attack the construction and, by melting out the lower-fusing-point mortar, get a grip on the interior of the wall. There is less infiltration into the furnace and less leakage of gases whenever pressures are developed.

The ganister made is a better non-conductor of heat than the original firebrick and it is possible to determine this by observing the temperature both on the outside of the boilers at corresponding points, and from the top of the arch. The ganister courses are distinctly cooler than the firebrick courses.

On account of these desirable conditions, it is possible to crowd the furnace harder than can be done with the usual firebrick construction, greater capacities can be maintained, and up to date the cost of maintenance is so much less that the two scarcely can be compared. The oldest furnace of this construction is now a little over four months old, and with twenty-five boilers so constructed not a single failure has as yet been recorded. Ratings above 275 per cent are developed from these boilers. Efficiencies have been improved due to reasons before described, and in general the experiment so far seems to be an entire success and a great improvement in furnace-lining construction.

Study of World's Water Powers Completed

More Than Half of Total Developed Water Power Is in North America—Africa has 190,000,000 Horsepower Potential Water Power and Only 11,000 Developed

THERE has recently been completed by the United States Geological Survey Part II of a "World Atlas of Commercial Geology," dealing with the water powers of the world. This atlas contains 35 pages of text 11 x 14 in. and 10 maps of the same size. The maps show the altitude of land, the annual precipitation and the location and extent of the water powers throughout the world, and set forth, in general terms, the resources and extent of their present development. This atlas represents the work of a score of men, most of them engineers, who made a careful search of the literature in several languages on this subject, and also made estimates where necessary. All available information was used in preparing the estimates of developed water power and the capacity of waterwheels now installed in water-power plants. The following abstract has been made from this geography:

North America, although it contains less than 15 per cent of the water-power resources of the globe, has developed more water power than all the rest of the world. About 41 per cent of the developed water powers of the world are in the United States. European countries, particularly Germany, the territory comprised in the former empire of Austria-Hungary, Norway, Sweden, France, Italy and Switzerland, have developed a relatively large percentage of their water power, and the percentage is greater in Germany than in any other country of Europe.

The potential water power of Switzerland has been estimated at 750,000 hp. at low water and 2,500,000 hp. for a flow available six months of the year, and one engineer estimates that 3,000,000 hp. may be developed at low water with storage. One of the interesting features of the developed water power in Switzerland is the large number of small plants. The plants having capacities below 20 hp. in 1918 numbered 6,025 and their total capacity was only 38,880 hp., or an average of about 6 hp. each. On Jan. 1, 1918, the number of plants of more than 20 hp. was 840 and their capacity at mean stage was 556,200 hp.

Nearly half of the 439,000,000 hp. potential water power in the world (or 190,000,000 hp.) is in Africa, but only about 11,000 hp. has been developed. The drainage basin of the Kongo River in Africa and its tributaries, covers about 1,500,000 square miles, nearly all of which is well watered. The Kongo affords greater water-power resources than any other river system in the world and more than all other rivers in Africa. In fact, more than one-quarter of the potential water power of the world is in this one river basin. Up to the present time this great resource is undeveloped. It is estimated that on this river for 90 miles, above tidewater, there can be developed more than 100,000,000 hp. Engineering problems for development would be exceedingly difficult and the construction of power plants on this section might be impractical even if a market were available for this enormous quantity of power.

The estimates of both the minimum and maximum horsepower given in Table I for the United States, are conservative. In some of the New England States complete developments would probably require installation of plants having a capacity of four times the estimated potential horsepower at low water. If all the water power in the United States were similarly developed, the total capacity of the plants would be 112,000,000 hp., and if this estimate is correct, the water-power resources of the United States are now only about 8 per cent developed.

Although the estimated potential water power of the world is nearly 440,000,000 hp. when the streams are at ordinary low-water stage and the present installed capacity at a little more than 23,000,000 hp., or more than 5 per cent of the estimated potential water power,

TABLE I. WATER-POWER RESOURCES AND INSTALLED CAPACITY OF WATER WHEELS IN THE UNITED STATES, BY STATES AND BY GEOGRAPHIC DIVISIONS, 1920

States and Divisions	Total Potential Water Power		Installed Capacity of Water Wheels
	Minimum Horsepower	Maximum Horsepower	Horsepower
New England			
Maine	443,000	809,000	412,000
New Hampshire	135,000	246,000	217,000
Vermont	94,000	172,000	223,000
Massachusetts	118,000	228,000	330,000
Rhode Island	6,000	13,000	43,000
Connecticut	72,000	137,000	156,000
Middle Atlantic division:			
New York	1,037,000	1,698,000	1,300,000
New Jersey	44,000	106,000	38,000
Pennsylvania	276,000	684,000	397,000
East North Central division:			
Ohio	59,000	178,000	54,000
Indiana	43,000	118,000	29,000
Illinois	192,000	345,000	84,000
Michigan	180,000	293,000	327,000
Wisconsin	358,000	670,000	318,000
West North Central division:			
Minnesota	232,000	494,000	224,000
Iowa	160,000	382,000	192,000
Missouri	72,000	163,000	27,000
North Dakota	88,000	207,000	400
South Dakota	43,000	75,000	18,000
Nebraska	196,000	366,000	18,000
Kansas	111,000	269,000	24,000
South Atlantic division:			
Delaware	5,000	11,000	8,000
Maryland and Dist. of Columbia	48,000	133,000	20,000
Virginia	492,000	870,000	157,000
West Virginia	381,000	1,051,000	20,500
North Carolina	578,000	875,000	370,000
South Carolina	460,000	677,000	453,000
Georgia	374,000	627,000	342,000
Florida	8,000	13,000	11,000
East South Central division:			
Kentucky	83,000	197,000	14,000
Tennessee	463,000	761,000	222,000
Alabama	509,000	943,000	260,000
Mississippi	32,000	69,000	8,500
West South Central division:			
Arkansas	22,000	61,000	6,100
Louisiana	1,000	2,000	4,000
Oklahoma	75,000	208,000	4,600
Texas	255,000	551,000	11,000
Mountain division:			
Montana	2,749,000	4,331,000	420,000
Idaho	2,362,000	5,067,000	243,000
Wyoming	773,000	1,305,000	6,600
Colorado	842,000	1,697,000	133,000
New Mexico	160,000	439,000	3,000
Arizona	893,000	1,698,000	52,000
Utah	743,000	1,318,000	122,000
Nevada	172,000	276,000	27,000
Pacific division:			
Washington	4,932,000	8,647,000	487,000
Oregon	3,148,000	6,613,000	295,000
California	3,424,000	7,818,000	1,111,000
Summary.			
New England	868,000	1,605,000	1,381,000
Middle Atlantic division	1,357,000	2,488,000	1,735,000
East North Central division	832,000	1,604,000	812,000
West North Central division	902,000	1,956,000	503,400
South Atlantic division	2,346,000	4,257,000	1,381,500
East South Central division	1,087,000	1,964,000	504,500
West South Central division	353,000	822,000	25,700
Mountain division	8,694,000	16,131,000	1,006,600
Pacific division	11,504,000	23,078,000	1,893,000
United States	27,943,000	53,905,000	9,242,700

probably only 2 or 3 per cent of the total potential water power has been developed. The extreme ultimate development with the greatest possible conservation of stream flow by storage may reach as high as 5 to 10 billion horsepower, but such a figure is purely speculative.

TABLE II. CAPACITY OF STATIONARY PRIME MOVERS IN THE UNITED STATES

Year	Horsepower — Total	Horsepower — Water Power	Percentage of Water Power
1900	17,500,000	3,300,000	18.8
1902	19,500,000	3,700,000	19.0
1904	22,500,000	4,100,000	18.2
1906	25,500,000	4,700,000	18.4
1908	29,000,000	5,360,000	18.5
1910	32,500,000	6,000,000	18.4
1912	36,000,000	6,700,000	18.6
1914	38,500,000	7,400,000	19.2
1916	42,000,000	8,200,000	19.5
1918	45,000,000	8,800,000	19.5
1920	49,000,000	9,500,000	19.4

NOTE.—The above estimates are based on the Conservation Commission's report of 1908; census reports of 1904, 1909, and 1914 on manufactures; and census reports of 1902, 1907, 1912, and 1917 on central electric stations and electric railways.

TABLE III. WATER POWER IN CANADA, JANUARY 1, 1920

Provinces	Horsepower Developed	Horsepower Undeveloped
Yukon	13,199	100,000
British Columbia	308,167	3,000,000
Alberta	32,992	466,000
Saskatchewan	.....	567,000
Manitoba	83,447	3,218,000
Ontario	1,015,726	5,800,000
Quebec	910,029	6,000,000
New Brunswick	18,080	300,000
Nova Scotia	34,323	100,000
Prince Edward Island	1,933	3,000
Newfoundland	60,000	400,000
Total	2,477,000	19,954,000

TABLE IV. DEVELOPED AND POTENTIAL WATER POWER OF THE WORLD IN 1920 IN HORSEPOWER

	Developed	Potential
North America	12,210,000	62,000,000
South America	424,000	54,000,000
Europe	8,877,000	45,000,000
Asia	1,160,000	71,000,000
Africa	11,000	190,000,000
Oceanica	147,000	17,000,000
Approximate total	23,000,000	439,000,000

New Type of Belt-Driven Air Compressor

A new line of belt-driven air compressors in which have been incorporated plate valves for both the air intake and discharge, is shown in Figs. 1 and 2. Each plate valve is supported throughout its operation in alignment without any form of wearing guide.

The unit is also equipped with a five-step clearance for regulating the compressor outfit. The compressor

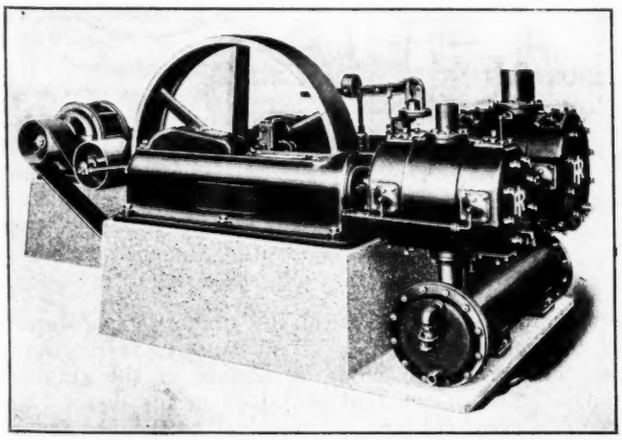


FIG. 1. COMPRESSOR WITH SHORT BELT DRIVE

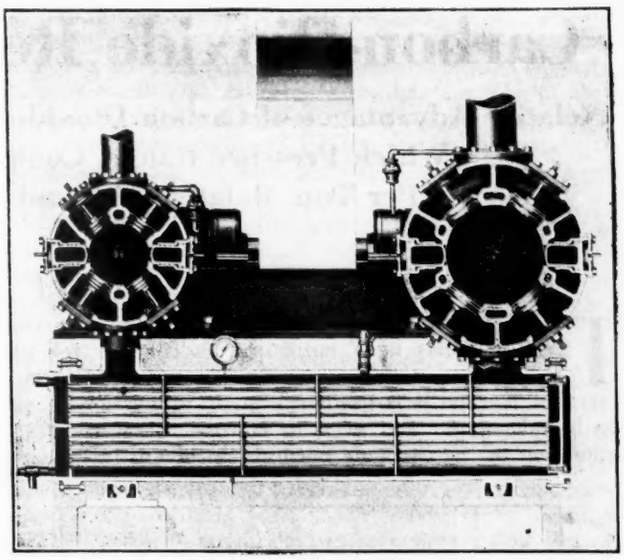


FIG. 2. SECTION THROUGH CYLINDER AND INTERCOOLER, SHOWING CLEARANCE VALVES AND POCKETS

is automatically loaded or unloaded in five successive steps, these steps being obtained by the reduction or addition of clearance space to the air cylinders. The compressor will operate at full, ¾, ½, ¼ and no loads, and the design of the clearance control is such as to secure efficient operation at any one step, the reduction in input power required being practically in proportion to the reduction in input capacity.

The control is automatic. If the compressor is operating at full load and the demand for air falls off, the control automatically causes the compressor to operate at one of the underload points, such as ¾, ½, ¼ or no load. When the demand for air is increased, the compressor assumes the load in successive steps.

The clearance pockets in the cylinder are automatically thrown in communication with the ends of each cylinder in proper succession, the process being controlled by a predetermined variation in the receiver pressure. With the compressor operating at partial capacity, a portion of the air is compressed into an added clearance space instead of passing through the discharge valves. On the return stroke this air expands, giving up its stored energy to the pistons. The inlet valves remain closed until the cylinder pressure equals the intake pressure. At this point the inlet valves are opened automatically and free air is taken into the cylinder for the remainder of the return stroke. Thus the inlet capacity is reduced without reducing the intake pressure.

Another feature is the maximum-demand stop, which will prevent the compressor from being operated at any higher maximum load than is desired. This can be adjusted so that the compressor will operate on a maximum of ¼, ½, ¾ or full load, and under conditions where the load factor is comparatively low, it is of value in reducing the maximum demand.

This belt-driven compressor, which is manufactured by the Ingersoll-Rand Co., 11 Broadway, New York City, equipped with clearance control, can be furnished single-stage for low pressures and two-stage for higher discharge pressure. The piston displacement capacity for 100.-lb. discharge pressure ranges from 610 to 1,505 cu.ft. of free air per minute.

Carbon-Dioxide Refrigerating Machine

Relative Advantages of Carbon Dioxide vs. Ammonia as a Refrigerating Medium, in Which Pressure Range, Cooling-Water Limitations, Horsepower Per Ton, Relative Size and Construction Are Considered

By H. J. MACINTIRE
Associate Professor of Refrigeration, University of Illinois

THE carbon-dioxide refrigerating machine is not new. It has been built in this country for 25 to 30 years, and in Great Britain and on the Continent of Europe it is used in a large proportion of all the installations. But even in Europe there has been opposition to the carbonic machine, although in numerous ways carbon dioxide has advantages far above any other refrigerant.

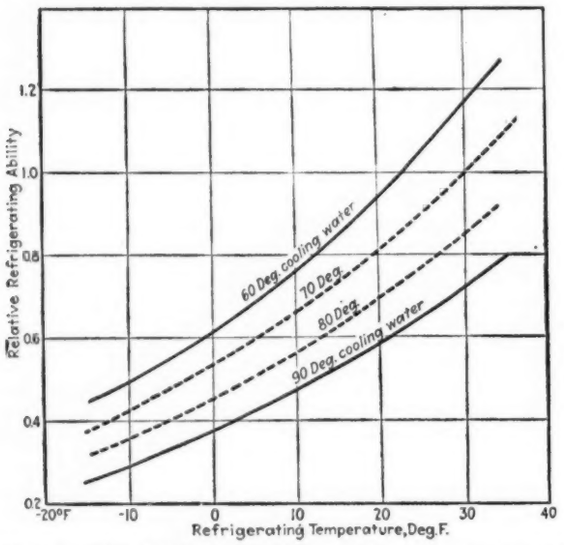


FIG. 1. RELATIVE REFRIGERATING EFFECT OF CO_2

In this country its application has been restricted in most part to marine work. Of late years its use has been extended to service in hotels, auditoriums, theaters and hospitals in congested quarters where safety from explosion is the big factor. The carbonic-machine manufacturers have used, apparently, the selling arguments of small piston displacement and "safety." Attempts to install these machines have been made only where safety was of first importance, from the viewpoints of the operator and the guests, the patients or the patrons who might be subjected to the fumes occasioned by an accident to the refrigerating system.

In brief the claim is made that, first, carbonic machines are subject to high pressures which make it hard to keep the system tight, and therefore great losses of the refrigerant are occasioned; second, that it is a cold cooling-water refrigerant, and that it cannot produce refrigeration with water of 80 deg. F., or above; and third, that the horsepower per ton is greater than for ammonia working under similar suction and head temperatures.

It is true that high pressures exist with carbonic refrigerating machines. The suction pressures usually range from 200 to 300 lb. and condenser pressures from 700 to 1,000 lb. per sq.in. But pressures like these are not necessarily difficult to employ or to keep tight. Although high gas pressures are not common, still they are not unknown, as is evidenced in the case of the Diesel oil engine and the steam automobile, both of which use unit pressures of 500 lb. or higher. The problem is mostly one of good material, careful design and good workmanship, conditions that could not be fulfilled in the early days of refrigeration. In general, the design of the system should be modified so as to include as little direct-expansion piping as possible, with as few joints as practical, but the plant should be self-contained with the condenser and brine cooler in close proximity to the compressor. Under these conditions, with care in maintaining the stuffing box, the carbonic machine should be as free from leaks as the ammonia system.

Cooling-Water Limitations

It is conceded that the carbonic refrigerating machine is primarily one for cool condensing water. It is desirable to bring the liquid CO_2 to the expansion valve at 70 deg. F. or lower, and under these conditions the horsepower per ton of refrigeration for the two refrigerants is about identical. At higher temperatures the carbonic machine falls off in capacity faster than does the ammonia machine on account of the greater relative effect of the heat contained in the liquid CO_2 at higher temperatures. It must not be thought for a moment, however, that refrigeration cannot be obtained with condensing-water temperatures of 80 or 90 deg. F.

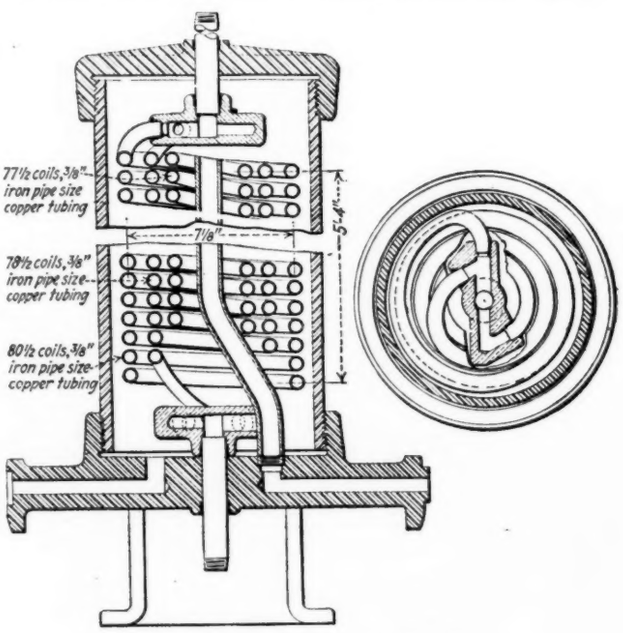

77½ coils, ⅜" iron pipe size copper tubing
78½ coils, ⅜" iron pipe size copper tubing
80½ coils, ⅜" iron pipe size copper tubing
7⅛"
51.4"

FIG. 2. SHELL CONDENSER

Practically all British refrigerated ships are equipped with carbonic machines, and likewise a large percentage of American ships. These ships are expected to cross the equator, pass through the Panama Canal or navigate in southern waters of 85 deg. F. or higher temperatures, and it is a well-known fact that refrigeration is obtained, although at capacities reduced by 30 to 50 per cent. It is frequently understood that, as carbon dioxide cannot be liquefied at a temperature above 88.6 deg. F. (the critical temperature), no refrigeration is possible under these conditions. Such an idea is erroneous, as is shown by the curves of Fig. 1 which represent experimental results.[1] Taking the refrigerating capacity of CO_2 as unity at 24 deg. boiling temperature, the curves show the relative refrigerating ability at various boiling temperatures and also with 60 and 90-deg. cooling water. The solid lines indicate test results and the dotted lines are interpolated. As will be shown later, the gas under high compressor discharge pressure will not condense, but will form a dense gas and will flow through the expansion valve in a manner similar to that of a liquid, part of the gas liquefying during the process.

As regards the power input for refrigerating machines, it may be said that this is nearly the same for all refrigerants working under the same temperature limits. The accompanying table is worked out with an idea of showing ammonia and CO_2, giving in each case the horsepower necessary to drive the compressor under ideal conditions.

As indicated in Table I, the horsepower per ton is somewhat greater for carbon dioxide than for ammonia, under the assumptions of no wiredrawing through the suction and the discharge valves, no leakage through the valves or past the piston and no clearance losses. Allowance is made in each case for the superheating of the gas during the suction stroke, and the cycle is taken as dry compression. As will be seen, the ammonia compressor is affected more by these factors unallowed for in the calculations than is carbon dioxide.

The carbonic refrigerating system uses a harmless, non-explosive, non-corroding and odorless gas. On account of the high density of the refrigerant it requires about one-sixth of the piston displacement necessary for ammonia when working under the usual temperature ranges, but on account of the high compression unit pressure, the diameter of the CO_2 piston is made small and the compressor has a stroke of three to four times the diameter. This results in the cylinder length, the crosshead guides, etc., being nearly the same length for the carbon dioxide as for the ammonia machine.

The suction- and discharge-pressure ratio in the carbonic machine is much less than the ratio in the ammonia compressor, in the former being 2 or 3, while in the ammonia system the ratio is from 6 to as high as 12. The pressure ratio determines the relation of the suction and discharge temperatures. It follows that with the same suction temperature in each machine the discharge temperature of the ammonia compressor is much greater than that of the carbonic compressor. Since the hot discharge gases heat the cylinder walls, piston head, valves and parts, the entering suction vapor coming into contact with these heated parts is superheated. This superheat is much greater in the ammonia compressor with its large pressure and temperature ratio.

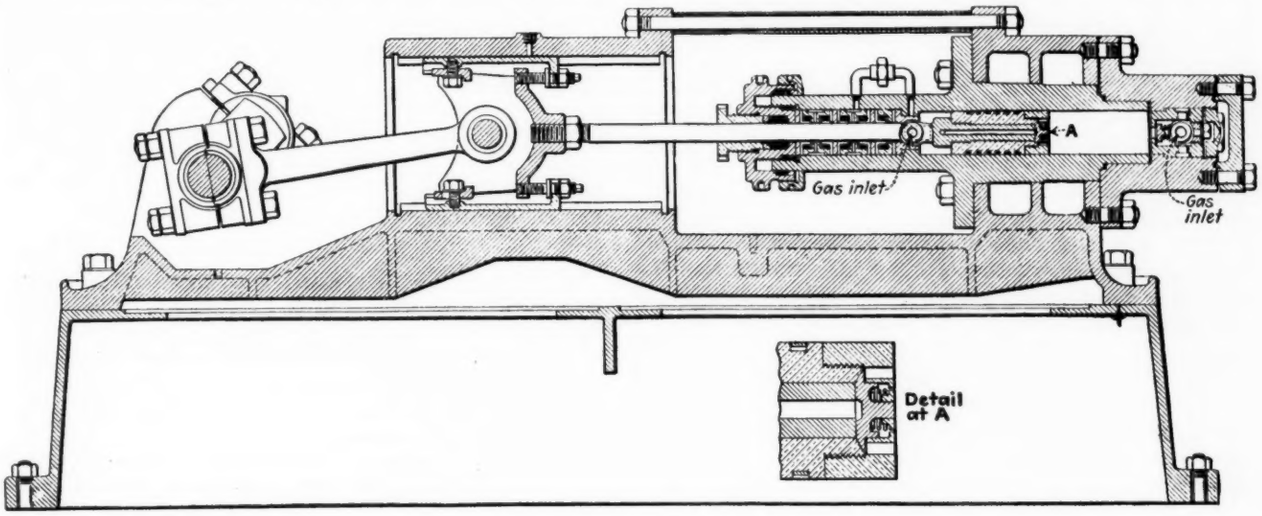


FIG. 8. CARBONIC-DIOXIDE COMPRESSOR

Superheating the gas means that less weight of the refrigerant is taken into the cylinder, and therefore the capacity of the machine is reduced accordingly. But with the CO_2 compressor there is no reason for much superheating of the suction gas, for with the small pressure ratio the discharge temperature is seldom higher than 200 deg. F. when the machine is operated correctly and the cylinder does not become so hot as with ammonia. In addition, the throttling loss due to wiredrawing through the valves is about one-tenth of the value that it is with ammonia, assuming 0 deg. boiling temperature of the refrigerant, and the same pressure drop in passing into the cylinder.

Because of the unit pressures of 800 to 1,200 lb. per sq.in., which may be brought on the system, the compressor cylinder was made formerly of forged steel, but now steel castings are used instead, and to a large extent the suction and discharge ports, as well as the seats for the valve cages, are drilled out of the solid material. The entire cylinder is usually made up of one piece, with only the head-end cylinder head removable, so that the piston does not pass over any joints in the bore. (See Fig. 3.) Clearance is usually made small, 3 to 5

[1] Liverpool Engineering Society, 1919.

per cent or less, although it is known that clearance itself does not cause a loss of economy and that the re-expansion in the clearance space with the small pressure ratio in carbonic machines is but 50 to 60 per cent of the re-expansion in the ordinary ammonia compressor.

All compressors should have safety valves and the carbonic compressor is no exception. The compressor may be vertical or horizontal, double- or single-acting, and it uses a type of suction and discharge valve similar to the ammonia valves. Recently, the carbon-dioxide manufacturers have followed the lead of the air and the ammonia compressor designers in installing low-lift plate valves of thin hardened steel, which, because of their slight inertia, will operate at high speed without trouble. This design is important where direct connection is desired with electric motors, as is frequently the case on marine work in which the direct-current motor is used, and in stationary work where the synchronous motor has become popular.

HORSEPOWER PER TON OF REFRIGERATION

Boiling temperature, Deg. F.	Cooling-Water Temperature, Deg. F. 60	65	70	75	88
Ammonia—10	1.1	1.2	1.3	1.4	1.5
Ammonia 0	0.90	0.95	1.07	1.15	1.24
Ammonia +10	0.70	0.78	0.84	0.93	1.06
Ammonia +20	0.55	0.62	0.70	0.80	0.88
CO_2 —10	1.35	1.52	1.68	1.85	2.0
CO_2 0	1.10	1.25	1.38	1.52	1.7
CO_2 +10	0.83	0.97	1.10	1.23	1.38
CO_2 +20	0.65	0.76	0.87	1.06	1.14

The piston is now made tight with piston rings instead of the old-fashioned leather cups. The leather cups were efficient, but were likely to burn if dry compression was used (and it should be used with carbonic machines whenever possible) and also was a limiting factor in regard to the piston speed. The double-acting compressors especially require a carefully designed stuffing box. This invariably is a combination of a lantern with leather cups and metallic or fiber packing. Glycerin is no longer used for lubrication, but a mineral oil of low freeze test instead. Carbon dioxide has no affinity for oil, nor does it dissolve in it or form emulsions, and so in this respect there are no troubles similar to those in ammonia machines.

Types of Condensers Used

With carbon dioxide the double-pipe condenser has been used almost exclusively in this country, with extra-heavy pipe and cast-iron fittings. In special cases copper pipe is used, as in marine work, or the submerged and atmospheric types have been used, where the double pipe cannot be installed on account of lack of room for full-length pipe or where the condensing water would not allow the use of double-pipe construction. Recently, the shell and coil condenser has been brought out, using copper coils of extra-heavy tubes for the condensing water, and the compressed gas and the liquid are piped inside the shell. This construction appears in Fig. 3. Because of the heavy unit pressures (these condensers are tested in the shops of 3,500 lb. per sq.in.) the shell is limited to 9 in. diameter (the 10-ton standard size) and the required capacity is obtained by adding the necessary number of 10-ton units.

Direct expansion, so well liked and successful with ammonia, is used only in exceptional cases with carbon dioxide. In fact, the author feels that successful operation of carbonic refrigerating machines depends to a large extent upon the elimination of leaks. Unless it is possible to reduce the leakage loss to an amount comparable with ammonia (especially at the present time, when CO_2 cost is one-half that of ammonia, instead of one-fifth), there are going to be serious objections to its installation, and of course the easiest way to prevent leaks is to reduce the number of fittings. This is possible with welded pipe or coils and by means of the reduction of the expansion piping by the use of brine coolers of careful design and good material and workmanship.

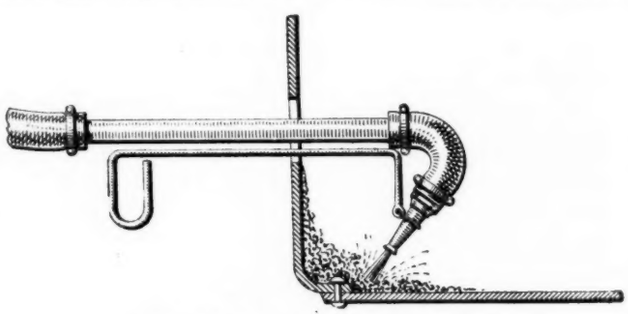
Summarizing the advantages and the disadvantages of the carbonic machine, it is a safe compressor, as has been demonstrated by discharging the entire carbon-dioxide charge into a congested engine room without serious after effects. The refrigerant does not explode during compression as CO_2 cannot burn or support combustion, whereas ammonia has been responsible for many serious explosions and fires. It is non-corrosive to metals and will not injure goods or commodities in storage. The compressor is much smaller in size, but the condenser must be of the same size unless copper coils are used, in which case the CO_2 condenser is much smaller than the ammonia condenser as the heat transmission through copper is greater than through iron, and copper or copper alloys cannot be used with ammonia. The losses due to clearance or to cylinder heating, are much less than with ammonia. On the other hand, the direct-expansion cycle is not practical for CO_2 save with small plants, and especial care must be taken to reduce the losses, which may be excessive on account of the lack of some convenient means of detecting the escape of the gas. Finally, it is best when used with cool condensing water.

Washing Scale from Corners of Boiler

By George G. McVicker

In cleaning steam boilers, such as have handholes in perhaps but two different points, it is difficult to remove the accumulated mud and scale by merely allowing the water to flow over them.

A device that may be used to direct a pressure stream to any part or corner of the interior of the boiler may be made with a short piece of hose and an iron rod.



HOSE FOR WASHING OUT CORNERS

In place of connecting the nozzle directly to the end of the pipe to be held by the operator, it is connected to one end of a 16-in. length of hose that is clamped over the pipe. An iron rod about 5 ft. long, depending on the size of the boiler, has a handle formed on one end and the other end is bent at nearly right angles, 8 in. from the tip end. This latter end is attached to the nozzle by wire or other means to form a flexible joint.

It will be seen from the illustration that the nozzle may thus be directed to any corner of the interior which otherwise would be reached only by chance.

EDITORIALS

Elimination of Waste Noteworthy in 1921

WITH this issue another milepost in time is past and the beginning of a new year is here. As has been the practice in the past, a large part of the first number in the year is devoted to a review of achievements in the power-plant field, for the past twelve months. In these times this review would not be complete without reference to other influences. In looking back over the past year, three words, "Elimination of Waste," stand out to mark 1921 as a year bringing new hopes and inspirations for the future. The elimination of the waste of war, the elimination of waste in our industries, the elimination of waste in utilizing our natural resources and human energy have all been centers of interest during the past twelve months. Although there are still many rough spots, a firm conviction is spreading throughout the world that it is better to follow the pursuits of life, liberty and happiness in peace, than to devote our time and energy to development and application of devices of death, destruction and misery.

Instead of a race for naval supremacy of the world, the three great powers have agreed on a ten-year holiday, as a result of the Armaments Limitation Conference held in Washington. This will result in the saving of billions of dollars to a world overburdened with debt and may have been the means of averting another bloody and costly war in the near future.

Instead of waiting until after a war has been fought at a cost of untold wealth, the destruction of millions of lives and the devastation of nations and then agree upon a peace conference to settle our differences, there is developing a realization that it is best to hold the peace conference first and try to work out a settlement of our differences without reverting to the destruction of war. In discussing the Four Power Pacific Treaty recently, President Harding declared that the hope of civilization lies in having peace conferences before wars instead of after them, and the big things aimed at are understandings for peace and an agreement to meet and discuss the preservation of peace whenever it is threatened.

In American industry the survey of industrial wastes, outlined by Herbert Hoover and carried out by American Engineering Council, will undoubtedly lead to tremendous savings. Although the American industrial machine has been considered the most effective in the world, nevertheless when only a part of it was weighed in the scale of modern efficiency, it was found to be woefully lacking.

The completion of the Superpower Survey by the United States Geological Survey marks not only the beginning of a comprehensive scheme in elimination of waste in generation and transmission of power for industrial purposes, but also in our transportation systems, which are now overtaxed to handle the traffic in this zone. Instead of building more railroads, it is proposed to increase the capacity of the present lines by electrification. An annual saving over steam operation of millions of dollars and millions of tons of coal will result as well as the savings to industries, and making possible the development of many water-power resources in this zone, that could not otherwise be economically developed.

The intense interest in the development of water power during the past year is a noteworthy step toward the elimination of waste in the utilization of our power resources. This interest has taken a concrete form in the installation of many thousands of horsepower of hydro-electric equipment, and applications filed with the Federal Power Commission involving millions of horsepower more.

In considering these accomplishments alone, it is not attributing too much to 1921 to say that the events of the past year will probably contribute more to the elimination of waste than all other movements in past human history.

Processing of Fuels

FROM the standpoint of fuel engineering one of the most interesting parts of the Superpower Report is the section prepared by O. P. Hood, of the Bureau of Mines, discussing the use of process fuels and pulverized coal for base-load steam-electric plants. Mr. Hood well points out that the processing of coal can be justified only if it serves one of two purposes; namely, the placing of the energy in the fuel in a more desirable form or the recovery of valuable byproducts. Starting from this premise and using certain unit costs, this very brief appendix shows in a striking manner the results (from a cost point of view) of processing fuels before using them in a steam-electric station. The most general and significant conclusion is stated clearly as follows:

> In a base-load steam-electric plant under present conditions coal must generally be used in the raw form in order to produce cheap power. Local conditions will justify certain exceptions to this practice. At large centers of population it may be found profitable to install process-fuel plants in conjunction with base-load steam-electric stations if the gas produced by the plants can be sold at a profit, particularly where a process is used that will yield gas having a high heat value that can be used to enrich water gas made by the gas companies.

In a fuel-processing plant one must provide income from byproducts ample to pay for the cost of processing plus the fixed charges, the investment usually being large. Excepting under favorable conditions for the disposal of gas—as, for example, in a city public-utility system—the income from gas and byproducts is seldom sufficient to justify using the coke for steam-electric stations. And unless the plant is so located that the coke itself brings a favorable price, the gas cannot usually be so employed.

The data which are presented, based on the unit costs used by the Superpower engineers, show that Clearfield coal at $6.25 per short ton is from one and one-half to four and one-half dollars cheaper per equivalent fuel

unit than coke from a byproduct coke oven, gas from bituminous gas producers, or semi-carbocoal from low-temperature distillation plants. However, it does also indicate that under favorable conditions for disposal of the coke, which is figured at a sale value of ten dollars per short ton, gas from a byproduct coke oven might be cheaper per equivalent fuel unit. Thus, the estimates indicate that the gas would be $1.21 less expensive per equivalent of one ton of the Clearfield coal.

In one sense the report is discouraging with respect to the processing of fuels for power production. Nevertheless, the limitations of coking fuel for power systems should be frankly and generally recognized. It is a limitation that is inherent in the processes of today. However, it does not mean that progress of tomorrow in the field of coking or low-temperature carbonization will permit the same relationship to prevail for the future. The efficiency of coal burning, even in the most modern types of boilers, is not by any means perfect. But the mechanical engineer has given much closer attention to the problems of coal combustion in boilers than he has to the problems of coal processing. It is probably safe to say that there remains a larger opportunity for the future in improvement of coking methods and of utilization of coke-oven products and byproducts than remains in the field of direct production of steam for power from raw coal. If this be the case, it is not too much to expect from the future that some fuel-processing methods will be developed that will place coke, semi-coke or gas upon at least an equal footing with raw coal for production of steam and power.

Two Kinds of Service

IN PRESENT-DAY salesmanship the word "Service" covers a wide variety of items that increase the value of the product offered. The design and manufacture of a piece of apparatus involve, in many cases, a great amount of study and research in order that it may be suited to the requirements for which it is sold. The results of this type of service are automatically delivered to the purchaser with the product.

For example, the design of a steam separator involves a study of the behavior of a mixture of steam and water in motion, as well as a knowledge of the individual properties of the vapor and liquid portions of the mixture. The results of this study must be combined with due attention to manufacturing requirements so that a satisfactory separator may be produced. The purchaser, therefore, buys not simply a piece of cast iron with perhaps some sheet-metal baffles, but he also receives the benefit of the manufacturer's research.

This research placed the manufacturer in a position to appreciate the limitations and faults of his apparatus, as well as its virtues, perhaps better than the user. Formerly, the latter too often bought a certain product because of the salesman's ability rather than because of his own knowledge of what would best meet the requirements. To protect the reputation of his own product, therefore, the manufacturer found that he must instruct the purchaser as to what would best meet the needs, and after the purchase was made see that the apparatus was properly installed and used. This involves supervision during erection and inspection, and instruction during the life of the product, as well as provision for the replacement of worn or broken parts. This is the part of "Service" that is most strongly emphasized at present.

There is another kind of "Service," however, that is not appreciated in many quarters. This appears in connection with advertising. Everybody who has something to sell must advertise. The newsboy on the street has his own advertising medium in the form of a good outfit of lungs and vocal chords, and he is just as truly an advertiser as the largest corporation with its staff of experts.

Some advertisers content themselves with a statement, dressed up in various attractive forms, of the superiority of their products. Others consider that such statements from an obviously interested source will carry more weight if backed up by reasons for the claims. The result of this latter and more constructive viewpoint is the production of a large amount of valuable technical literature. This is a most important part of the "Service" rendered by manufacturers and is available, not only to purchasers, but to the engineering world in general. One place to find it is in the advertising pages of engineering periodicals, and it is the wide-awake engineer that will scan the advertising pages with an interest second only to that applied to the editorial matter.

Here, then, is an item of "Service" that supplements that of supplying a perfected product and the service of instruction and inspection in connection with the erection and use of the apparatus after purchase. The fact that this is rendered as a part of advertising and not as a philanthropy does not detract from its value.

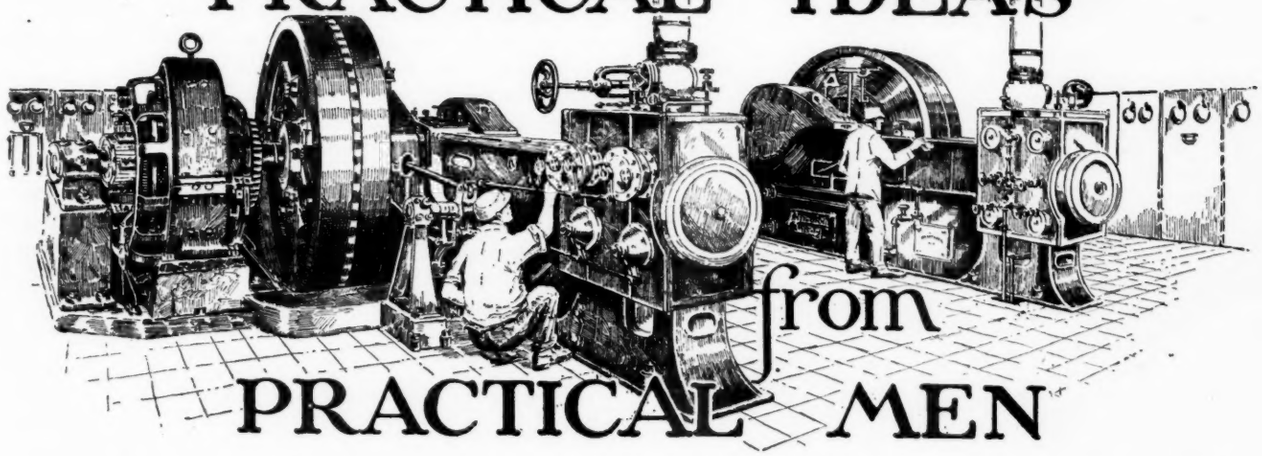
Leaks in steam, water and air lines may continue indefinitely without causing any serious trouble, but the losses are going on all the time. This is equally true of uninsulated steam and hot-water lines. With an electric circuit appreciable leaks cannot continue for any length of time without causing trouble that will call attention to the defect in no unmistakable terms and require a repair before operation can be continued. If this were only true of other systems of transmitting energy, it would not be necessary to do so much talking about methods of preventing losses.

The old adage, "Half a loaf is better than none," certainly should be applied now more than ever before. Small and relatively inexpensive equipment making for improvement, long delayed overhauling of plant facilities and new plant practice which has been considered often but never tried out, are available usually at little or no extra expense. They furnish an ideal "half loaf." Why not use them instead of waiting in a despondent frame of mind until the big new installation can be realized?

One of the astounding things about a man is that after he is doing his best, he can still do a little better if it is made sufficiently worth while for him to do so. This kind of service cannot be obtained, however, unless he knows that his good work will be discovered and rewarded. Adequate records combined with a liberal system of pay and promotion are essential.

A high coal bill is not necessarily the fault of the boiler-room force. Where process steam is supplied for manufacturing purposes, it is often used most wastefully. The best way to fix the responsibility and check the waste is to meter the steam going to the various consuming departments.

PRACTICAL IDEAS from PRACTICAL MEN



Why the "Toy" Was Purchased

It was an ordinary power plant in an ordinary office building in a certain city. The chief engineer had just had a new CO_2 machine installed, and the fireman stood regarding it with disdain and skepticism. Turning to the chief, he said: "The company must have plenty of money when it will spend it for a toy like that. What's the idea?"

"You think it's a toy; you think that the company is throwing away its money, do you?" inquired the chief, as he jerked his thumb toward the CO_2 machine. "Well, if you can stop scratching matches on the seat of your pants that is so blamed shiny that there's no friction there, in your attempt to keep that low-grade combustible you call tobacco going in your inefficient downdraft furnace, I'll tell you a few things.

"If you had paid any attention to the coal reports for the past several months you would have seen that more coal was burned here during the month of August than during July or October. I ain't blaming you, mind you, for that. It was the result of circumstances, that's all.

"No, I didn't suppose you would remember anything about the coal, but just so you won't get the idea that I don't remember, you just slant your ear this way and imagine you are listening to words of wisdom. During the month of August we burned fourteen tons more coal than we did in September. That means $98 more for coal and a couple of dollars more for the cost of carting away extra ashes, and I'll bet the price of a cheap cigar that you don't know the why of it any more than you know why big and little apples grow on the same tree."

"Sure, I know," replied the fireman. "We burned more coal because we burned more coal. We had to keep up steam, didn't we, and you know that takes coal as well as I do."

"Ye Gods! It's strange I never thought of that, but you're off your game so bad that you wouldn't make your eighteenth hole in 450 and the ——"

"What do you mean with your eighteen holes in 450? Am I supposed to be playing pool or marbles?"

"'Tis neither," replied the chief. "I thought you was a golf player by the way I seen you drive coal into the furnace. But to get back to dissecting the body. The reason for throwing away $100 in the shape of fourteen tons of coal was because neither of us was on the job."

"You can speak for yourself," retorted the fireman. "I don't know where you was, but I was here in front of these boilers."

"Sure you was, but that didn't mean that you was onto your job. It means that you were getting paid for what you were supposed to do but didn't. I wasn't on the job either, because the first two weeks of August I was busy with other things and didn't visit the boiler room as often as I should, and things began to get ragged on the edge. Then I took a vacation during the last two weeks of the month and things went straight to Hell Gate or some other place. In other words, I didn't see to it that you kept your fires in proper condition while I was here, and you didn't give a hoot how they were kept while I was on my vacation. Holes, dirty fire, punk draft regulation and other little things that were neglected is what caused you to handle fourteen tons more coal than there was any need of doing."

"Hellcats! I never thought of it in that way. I sure did make work for myself. Gee! Fourteen tons handled for nothing! That's tough!"

"Yes, that's tough!" was the chief's sarcastic reply. "You did a lot of extra work just because I wasn't here to prevent your doing it. The next thing you know you will need someone to tell you how to start for home before you get here. But this little toy, as you call it, is going to do the watching after this, and if you have got the sense of a one-eyed clam you will do just what I tell you to do."

"Can the blamed thing talk?"

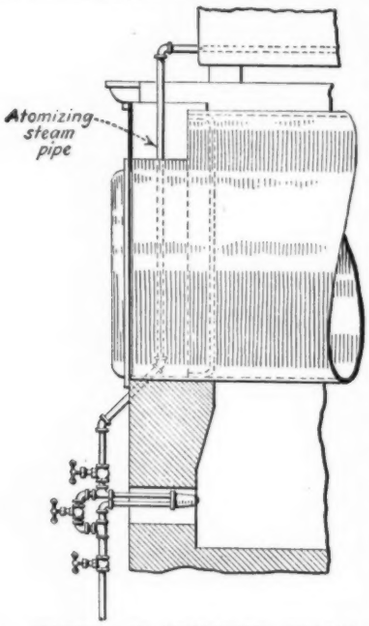
"Sure thing," replied the chief; "not in the language that you understand, but it will. You are going to get education even though you don't know it. That toy is going to tell you when you have holes in your fire, and I won't have to come down here to look into the furnace to find out when they are there, either. It is going to tell you when the fires are too thick or dirty, when the draft is not right, how long you have the firedoor open while you are lighting that cussed pipe of yours and trying to fire at the same time, and it's going to tell a lot of other things.

"Unless I miss my guess, it's going to make you shovel less coal and will save the company enough money to pay for itself in just about four months. That is what the toy is for and that is why the company is spending money for it. Now come on out here, you long-legged shrimp, and begin your neglected education while I expound to you what the line on the chart means and why it hasn't made a nice inked-in ring instead of looking as if it was representing a river on a map.

New York City. P. W. CURTIS.

Preventing Atomization Accidents with Fuel Oil

It is the experience of everyone who has had to do with oil-burning equipment that various extremely unpleasant things happen whenever a little water comes down the pipe that supplies the steam for atomization.



PIPING OF ATOMIZER STEAM LINE

The flame momentarily ceases, and the mixture of oil and water is thrown for an instant upon the incandescent interior of the furnace. This mixture vaporizes instantaneously, and the volume of vapor formed frequently ignites explosively. I have seen bricks shaken down, and firemen have been badly burned about the face, because of explosions taking place when they were in the process of regulating the fires. One cannot regulate an oil fire by instinct. With superheater-equipped boilers, and in fact with water-tube boilers, such explosions seldom or never occur; but in case of fire-tube boilers and with the usual steam connections for atomization, considerable trouble may be met with from this source.

The illustration suggests a simple remedy. The atomization line to each burner is led through the smokebox, and through the breeching if preferred, to the main header. If the heating surface of the boiler is so efficient that a single pipe through the smokebox will not dry the steam, put in a little coil, being careful to keep it out of the way of the tube cleaner. Any slight superheat that the atomizing steam may thus acquire may be considered as an economy, for it is really warming up the oil by waste heat..

Lafayette, Ind. WILLIAM E. K. MIDDLETON.

Caring for Sprinkler Tanks in Winter

Freezing and bursting of sprinkler-tank piping is a serious matter to any engineer. All steam piping, including the coil in the tank, should be of brass with heavy brass fittings. This is the cheapest in the end, as it is good for about twenty years of service. Iron pipe will usually last less than five years, and will then necessitate digging, scaffolding and removing the triple wooden jacket which covers the stand pipe.

The man who fits on the standpipe jacket should be watched and cautioned not to fasten and brace the steam pipe, as interference with expansion and contraction will eventually cause crystallization and breakage.

There should be provided means for viewing the returns in order to watch the quantity and temperature, for if the quantity is small and the temperature is low there is danger of freezing. If, however, the pipe should freeze up, it can usually be thawed out by sending a jet of steam into the wood lagging. This will rise to the top of the standpipe and thaw the pipe.

There should be a permanent platform under every tank to enable the engineer to look after the stuffing box, also a ladder both inside and outside of tank.

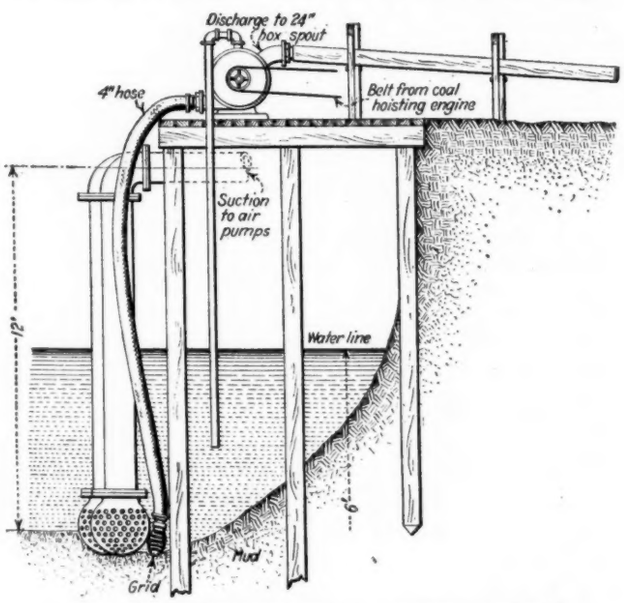
The most reliable way to tell if the tank is full is to overflow it. If this cannot be done, a simple pneumatic mercury gage is best in all weather. Many engineers do not realize that if water at 80 lb. pressure is turned into a tank, the water of which is covered with six inches of ice, it may cause a leak, or that a vacuum will interfere with the water leaving the tank in case of fire, or that if the ice falls to the bottom of the tank after the water is let out it will smash the steam coil.

Albany, N. Y. C. HAMSSER.

Cleaning Strainers on Suction Pipes

In a power plant near New York City the circulating water for the condensers was taken from a tidewater creek having a bottom of very soft mud. The strainers on the ends of the pipes were located close to the bottom, and even at that, at an extremely low tide they would be only barely covered with water. At such times the strong suction would draw the mud up around the strainers and cleaning them would become almost a continuous performance. A man would have to go down on a vertical ladder and cling on with one hand and, with a long-handled spade in the other, dig and scrape the soft mud away—certainly, no desirable job, especially in the winter-time.

A second-hand 24-in. "sandsucker" dredging pump was procured at small cost and installed on the wharf, as shown in the sketch, and belted to the coal-hoisting



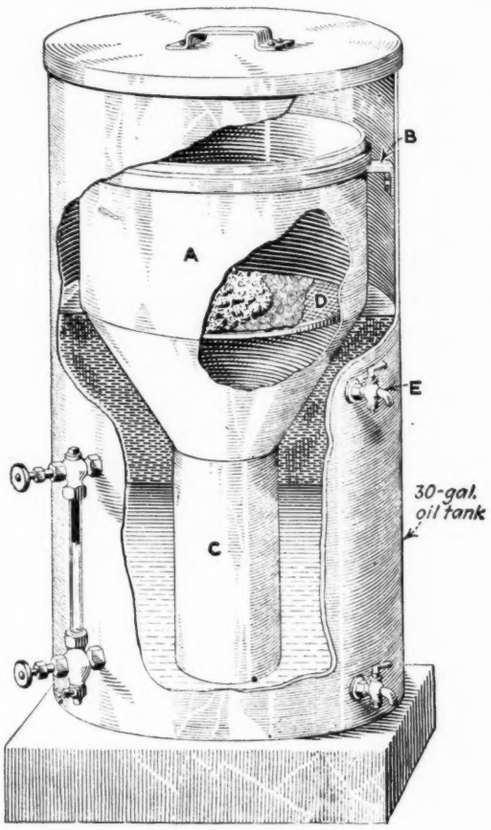
HOW THE STRAINER WAS CLEANED OF MUD

engine. A 4-in. rubber suction hose reinforced with copper rings, extended down to the mud, with a cast-iron grid on the end to prevent stones large enough to wreck the pump from coming up. A box spout was carried a short distance to low ground. Now the man on the ladder has only to keep moving the hose about, and in a few minutes a space around the strainers can be excavated that will take a week or more to fill up.

Camden, Me. M. M. BROWN.

Didn't Have an Oil Filter, So Made One

It was not much of a plant as they are rated at the present time, but as it was my first one, it looked mighty good to me. The three generators were belt-driven from a lineshaft, and each was lubricated by means of oil cups, the oil dropping into pans that were placed



DETAILS OF THE OIL FILTER

under each bearing. This oil was dumped into a small tank and used a few times and was then thrown out on the coal pile.

In one corner of the boiler room was a barrel about half full of used oil, and nobody about the place knew how long this oil had been on hand.

Throwing good oil on the coal pile did not appeal to me, and in hunting around the plant an old 30-gal. air tank was found and one end was removed and a deep tray made to fit inside as shown at *A*, being suspended on lugs *B* which were riveted to the shell of the tank. The bottom of the tray was made cone-shaped to receive a spout *C*, which was soldered in place. A ring *D* was made to fit in the tray, and on it a disc of heavy fine-mesh wire was placed, and on this screen came several layers of cheesecloth and on top of that a layer of clean waste.

Two gage-glass connections were removed from an old steam trap and attached to the filter so that the level of oil and water could be readily determined. Water is kept at a level to show at about 1 inch from the top of the glass. Oil is drawn off from the filter through the cock *E*. The lower gage-glass connection is about four inches from the bottom of the tank.

All oil to be filtered is poured in at the top of the filter and passing through the layer of waste and cheesecloth, trickles down through the spout *C* and discharges into the water space of the filter and then filters up through the water, ready for draining off as wanted. The filter is drained of water through the bottom cock.

Denver, Col. W. H. PIERCE.

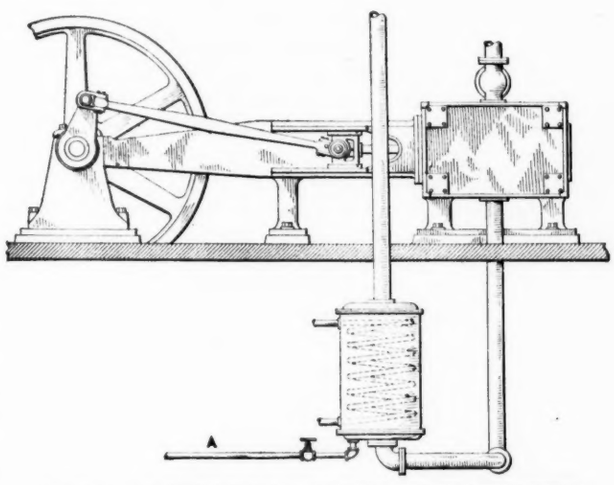
With the Heater Flooded, What Would Happen When Starting Up?

In a certain steam plant there is a four-valve engine, the exhaust valves of which are of the semi-rotary type. The exhaust pipe from the engine drops and extends horizontally to a pumproom, the floor of which is considerably lower than that of the engine room. A closed heater is installed in the pumproom, the exhaust from the engine connecting at the bottom, and after the steam passes through the heater, it exhausts vertically through the roof, as shown by the sketch.

The top of the heater is considerably below the bottom of the engine cylinder, and the question arises, as to what would happen to the engine in case the heater became flooded. This is what happened, and the engineer is not sure as to whether he saved a cylinder head by shutting down or not.

The heater is fitted with a drain pipe *A*, the valve being left open at night and over Sunday. This was done on shutting down on Saturday. On Monday morning the engineer observed that the drip valve was open and naturally supposed that the heater was free of water. As a matter of fact it was probably about half filled, as the drip pipe had frozen solid at the discharge end, which was outdoors.

Upon starting up slowly, the engineer heard a thumping and splashing sound in the pumproom. Investigation showed that the noise came from the heater. Knowing that it could be caused by no other agency than water, he stopped the engine, which was moving but slowly, and then freed the drain pipe of ice and drained the heater, after which he concluded that he could start up to full speed with safety.



PIPING OF ENGINE TO HEATER AND DRIP PIPE

Could he have brought the engine up to speed with the water in the heater without the danger of water being drawn into the cylinder when the exhaust valve opened, or would the water have been blown out through the exhaust pipe onto the roof? J. P. BURGGRAF.

Cleveland, Ohio.

About Ready for the Scrap Pile

Upon an inspection of the plant of a large public-utility company engaged in the manufacture of light power, ice and cold storage, I observed the following conditions: The plant was located upon a nice plot of ground, and the boiler-room side of what should have been a pretty lawn was stacked with old barrels, trash, machinery and at least a carload of brickbats formerly used in the boiler room. In the rear of the plant and on both sides was another accumulation of old lumber and other rubbish. The smokestack guy-line posts were rotten at the ground, and they had been renewed from time to time, which was an unnecessary expense as the massive brick walls of the building could have been used to anchor the guy wires by means of eye-bolts, which would not only have removed the guy lines from the ground and out of the way, but would have enhanced the architectural and landscape beauty of the surrounding.

Upon entering the boiler room, I observed a hand CO_2 instrument practically destroyed by rust; draft-gage instruments were detached and out of commission; the baffle plates were practically all out of the water-tube boiler. The plant was burning crude oil, and an excessive amount of air entered the furnaces through the firedoor openings, the door having been removed and the openings roughly bricked up. This air leakage, coupled with a leaky furnace setting, furnished an abundance of excess air.

The two fuel-oil pumps were in poor condition, as the piston rings in the steam end of each, also the valves and seats, were so badly cut and scored that the pumps would barely operate with 150 lb. steam pressure.

Upon entering the large and systematically arranged engine room, I glanced over the illuminated switchboard and saw a neat danger sign above the switchboard, lettered in red, "High Voltage—Danger," but the concrete floor was lacking the rubber mat which is as essential to eliminating casualties to the operator as the safety valve is to prevent an explosion of the boiler.

The turbine condenser was carrying but 24 in. of vacuum, which I was advised was because the wet vacuum pump was in poor condition. Later I saw the direct-connected engine to this pump slow down at 145 lb. steam pressure, and the engineer advised me that it took 150 lb. to keep it up to speed. An examination disclosed that the valves, seats and rings in this unit were practically worn out. The same condition was noted of the other turbine auxiliaries.

The generator collector brushes had seen their best days, and the engine driving the generator was hammering away with a loose crankpin and quarter-box bearings.

A 35-ton ice machine was next investigated, and the rings in the steam-cylinder pistons were missing. The valves were improperly set, and at least four barrels of lubricating oil was found in the system. The ammonia compressor showed the top valves so corroded that it took a sledgehammer and a block of wood to move them from their cage, and it took a machinist four days to regrind them. The stop valves on the compressors of the suction and discharge were in similar condition.

In another part of the engine room was a 50-ton belt-driven ice machine, motor-driven by a two-ply 40-in. leather belt 100 ft. in length over all. There was not enough clearance between the bottom lap of the belt to prevent it, especially when shutting down, from slapping the cement and brickwork underneath. This obstruction proved to be an old cement engine foundation that could easily have been removed at a moderate cost by using an air hammer and rock chisel, thereby considerably prolonging the life of an expensive leather belt.

The water supply for this institution came from a flowing well somewhat over 1,000 ft. in depth, which would not furnish sufficient water. It was found upon investigation that the pipe was choked down to about equal to a 4-in. discharge pipe. This was corrected to supply more than the necessary quantity of water by cleaning the pipe to its original 8-in. outlet and placing 200 ft. of air line in the well, using compressed air at 50 lb. pressure.

H. W. ROSE.

Victoria, Tex.

How One Plant Saved by Selling Exhaust Steam

We hear and read much these days about wasting coal, and it is surprising, when one looks into the matter, how great the waste is. In 1916 I became superintendent of the municipal plant at Montpelier, Ohio. At that time we were buying coal at $1.15 a ton; in less than a year we paid as high as $4.50 f.o.b. mine and it was hard to get at that. One block distant from the plant were two hotels that were equipped with hot-water heating plants, and of course they also had trouble to secure coal. As the municipal plant ran non-condensing, I persuaded the hotel men, after a good deal of argument, to run a pipe line from the plant and heat with exhaust steam. All the expense to the plant was in connecting the line to the exhaust line within the plant—about $60 in all.

In the hotels the discharge line from the boilers was disconnected and a steam connection made, and the return was so arranged that the boiler served for a trap. Because of this arrangement, if it happened that steam was shut off for any reason, the boiler could be filled and used as before the change. The hotels had small water heaters for domestic use. I suggested that the water be heated with steam, and a tank was procured and steam coil put in it. One of the hotels had a steam table, and it was connected up and worked satisfactorily.

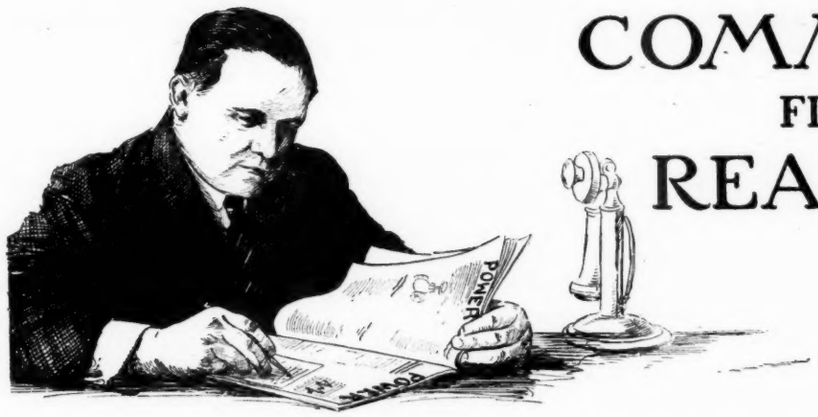
This was a railroad town, and a large number of locomotive engineers who lived at one of the hotels claimed the system would never work, as it would require 15 lb. pressure to drive the steam to the hotel.

The service was connected up, and a gage on the exhaust-steam line showed that there was not enough pressure to raise the gage pointer off its pin. The city received $350 a year, and it cost the hotels about one-half as much for heating as formerly; there was a saving on labor as well.

This arrangement proved so satisfactory that the next year three residents in the same block installed steam heat, and still there was enough steam exhausting through the roof to heat several times as many buildings, despite the fact that there was not enough steam to heat one hotel according to some men's ideas. As the hotel heating plants were put in as a hot-water system, the only trouble in using steam was that they were kept too hot.

The hotel manager would not have this steam taken out for double what it cost, and the plant is in $350 per year from the hotels and $160 from the residents.

Sandusky, Ohio. A. G. C. MCKALIP.



COMMENTS FROM READERS

What Charge Should Be Made for Steam?

The question of distributing our power-house charges has recently come to the front, and as the problem is rather complicated, we are writing you for your advice on the matter.

We are operating a General Electric mixed-flow turbine condensing. The high-pressure steam to the turbine is measured by means of a Bailey fluid meter. From the feeder to the turbine a small turbine driving the circulating-water pump is also fed. Exhaust steam is supplied from the stoker engines, forced-draft fans, boiler-feed pumps, air compresors and circulating-water pump. None of the steam to these is metered, but we have sufficient information to estimate the steam consumption fairly accurately.

We supply the factory with steam at 125 lb., steam heat, hot water, low-pressure air, high-pressure air and electricity. Taking these in the order mentioned, the conditions are as follows:

Steam to Factory—Metered.

Steam Heat—We propose measuring condensate from vacuum pumps. Heat is taken from exhaust steam and made up with live steam out of factory feeder, but before steam to factory is metered.

Hot Water—Controlled by thermostat. We purpose measuring the amount of water going into the heater.

Low-Pressure Air (30 lb.)—Steam not measured. We have automatic counters on the compressor so that the total revolutions are known. From this we calculate air delivered and steam used.

High-Pressure Air (80 lb.)—Furnished by means of two Westinghouse air-brake compressors. This is used is small quantities, and we think that this charge might properly be absorbed with the other auxiliaries to appear later in steam, low-pressure air and electricity. Our coal is weighed by means of a larry and the water measured by a V-Notch meter.

Should the turbine be charged not only with live steam but also with a fraction of the exhaust steam? If so, should the air compressors be credited with the exhaust steam charged? How much should the factory be charged for steam, and how much should the compressor and turbine be charged? G. H. LEWIS.

Corning, N. Y.

[The foregoing inquiry was referred to Wilfred A. Miller, author of the series of articles on Power-Plant Accounts that ran in *Power* from Sept. 13 to Dec. 27, 1921. His reply follows.—Editor.]

Simplicity in accounting makes it desirable to exclude from the bookkeeping procedure any items of credit for exhaust or condensate returned by any of the steam demands of a plant. If it were considered expedient to adopt such a system, proper weight should be accorded the state as well as the quantity of heat supplied and returned.

Ordinarly, a convenient way of looking at the problem is to consider all returned exhaust and condensate as belonging to the steam-generating department without credit to the source of the return, such exhaust being at the disposal of the department to make use of either for its own purpose, such as feed-water heating, or for redistribution to other departments, as is the case in the present inquiry. In this latter event it is of course necessary that the exhaust that is redistributed be charged for. The rate of charge per unit quantity of the exhaust should, theoretically, be less than that for live steam, but in average practice there is so little difference in heat content that the complication entailed seems scarcely warranted. However, if it is desired, a ratio for average conditions can be determined upon.

To arrive at unit rates, the ratio determined upon may be applied to the exhaust-steam consumption to adjust it to the basis of live steam equivalent, and this be added to the actual live-steam load. As an example, let it be assumed that the live-steam consumption amounts to 100,000 lb. and the exhaust to 25,000 lb. If the ratio is 1 to 0.8, the exhaust steam would be equivalent to 20,000 lb. of live steam, and the total steam supplied could be considered as being 120,000 lb. of live steam. The rate per pound could then readily be determined by dividing this quantity into the total cost of steam generation for the period. The known live-steam consumption would then be charged at this rate, and the exhaust steam at 80 per cent of it.

In the problem submitted it would be necessary to secure information regarding the following steam consumption: Live steam (a) to turbine, (b) to factory, (c) to steam-heating system, (d) to low-pressure air and (e) to high-pressure air; exhaust steam (f) to turbine, (g) to heating system and (h) to hot water. It appears that means are available for determining, either directly or indirectly, the quantities corresponding to (a), (b), (d), (h), and the sum (c) + (g). It would therefore remain to provide for the determination of (e) and (f) and the separation of (c) + (g) into its components. The latter could be accomplished if either one of them is determinable. With regard to (e) it would be permissible to omit this, as suggested in the inquiry, if the demand is very small as compared with the others. Otherwise it would seem to be pre-

ferable to devise some arbitrary method of arriving at an approximation of it.

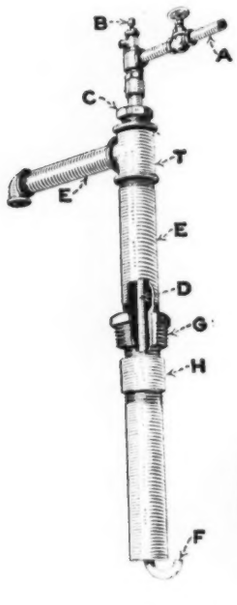
If (r) were to represent the value ratio between live and exhaust steam, the cost per pound of steam for a period would be expressed as follows:

$$\text{Cost of steam per pound} = \frac{\text{Total cost of steam generation for period}}{(a) + (b) + (c) + (d) + (e) + (r) \times [(f) + (g) + (h)]}$$

New York City. WILFRED A. MILLER.

Emptying Oil Barrels with Compressed Air

After noting different readers' experiences in unloading oil barrels with air, I submit two methods that I have used. The one shown in Fig. 1 is used on low lifts. The air supply pipe *A* is fitted with a relief valve *B* which is set to operate at low pressure. The air pipe



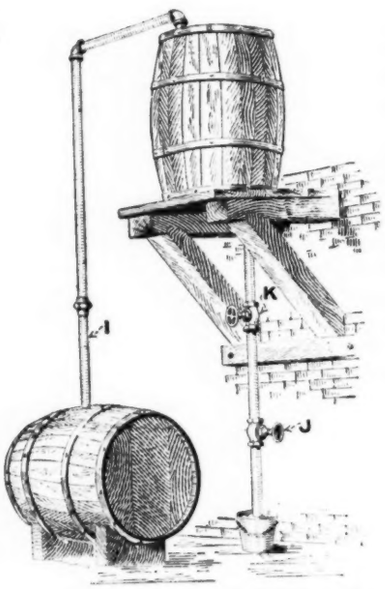


FIG. 1. FOR LOW LIFTS. FIG. 2. FOR HIGHER LIFTS.

passes through a bushing *C* and brass pipe *D* to the bottom of the pipe *E*, where it is turned up slightly, as shown at *F*.

When air is turned on, it forces the oil out through *T* and the pipe *E*, which is threaded sufficiently to go through the bushing *G* into the coupling *H*. An extension pipe is screwed into the coupling and reaches to the lowest part of the barrel or drum.

We have two of these, one for emptying from the side and one from the end of the barrels. Both are made of 1¼-in. pipe, but occasionally a barrel comes in with too small a bung for the bushing *G*. This could be remedied by using 1-in. pipe.

Fig. 2 shows a method I have found satisfactory for lifting oil to a platform or upper floor within any reasonable distance. The top barrel is filled with water, making sure that the pipe *I* reaches as nearly as possible to lowest part of lower barrel. The valve *J* is fitted to open into a water bucket or other water seal to prevent air from passing back into the discharge line *I*. In operation the oil will be forced by atmospheric pressure up and into the top of the upper barrel as fast as the water runs out of it.

A valve can be placed in the water-discharge pipe at any convenient location, as at *K*, where the oil can be drawn off from the upper barrel as wanted.

I have used this method with excellent results in lifting heavy cylinder oil. R. E. KEECH.

East Akron, Ohio.

Three Methods of Firing a Boiler

I recently read a letter by a contributor on different methods of firing. Having had to learn while earning, with over thirty-three years of practical experience as a fireman and engineer, I feel qualified to make a few remarks on the subject that are not perhaps altogether senseless. I do not mean to give the impression that I know it all, but I was a good fireman, making a study of my work because I liked it and could see the chance for improvement in the methods then in vogue.

Consider the work of the average fireman in a plant of from 5,000 to 20,000 sq.ft. boilers. He goes to his work wishing that he was on his way home instead. He is going to get through his "watch" with as little effort as possible, and he has no desire to experiment in the endeavor to save fuel. Probably the first thing he does is to clean fires, a task dreaded by nine out of every ten firemen, but one that has to be done nevertheless.

After the job is finished and the fires are built up to a good working depth, if the fireman is interested in saving fuel and desires to distinguish himself from his fellows, then is the time to do it by keeping a clean fire. By using his head he can get through his watch comfortably, and at the same time make himself worth more to his employer and save fuel by handling it so as to get the most heat and the least smoke out of the coal he handles.

What he actually does is something like this: First, he shovels about half a ton of coal into one side of the furnace, taking care to get the most of it well back to the bridge wall; he then assumes a position of ease in some favorite spot and waits for the pointer to begin to fall back toward zero; then he grasps his trusty slice bar and proceeds to ram it in under the amalgamated mass of dead fuel and lets the air mix into it. In a few moments he will have a glowing mass on that side of the furnace, eighteen inches or more deep, and the other side is ready for a similar treatment. In this way he manages to keep the steam pressure somewhere near what is required.

Owing to his ability to do this, reckoning the amount of needless work he has done, and the black smoke he has turned loose on a long-suffering public, he gets the name of being a good fireman and is always able to get a pile of coal to waste and boilers to waste it under, and to draw pay for wasting it.

Firemen with strong backs, small brains and no ambition for the future are getting harder to find in the power-house boiler room. What sort of man takes up the task where "Strong Back" left off? He is of a different type. He has been told that a level, even fire is the best to carry and light firing at frequent intervals is the proper method, and he proceeds accordingly. After his fires are cleaned, he is in almost perpetual motion until the end of his watch. He isn't looking for a soft job; he wants to do his work right and keep his

job and does all he knows how to give satisfactory service. He is a big improvement on "Strong Back," and some day he will get in with the right sort of boss, who will show him a few things. He will also wake up and find out a lot more for himself. He gives way to the third-trick man in due time, and goes home tired out, but with the knowledge that he has done his level best.

Watch the third man and see how he goes at his work. There is something about him that is different from the other two. His first move is to start at one end of the battery of boilers and blow down the water columns and gage glasses, try the gage cocks, test the feed-water valves; he gives a brief glance to note the condition of the fires before proceeding along the line to the next boiler. This he continues to do with each one to the end of the line. He then returns to the first boiler and arranges the fire to his satisfaction. The chances are that he will move the most of this fire over to one side of the furnace and shovel on a few scoops of coal on that side, leaving the other side to burn down ready for cleaning. He will then go over the other fires, leveling them and adding a few shovels of coal to the front of each as he goes along. He is in no hurry —there is no need of it; the steam has risen to the proper pressure, and that is the main object for his being where he is.

Finally, having arranged the fires to his satisfaction, he will, perhaps, visit the feed pump and see that the lubricators are supplied with oil and everything else in proper condition. By this time one fire is ready to clean, and it is worth while to watch the process. First, the needed tools are arranged within convenient reach, and with a glance at the gages to make sure that all is as it should be along the line, he opens the door to the furnace, first partly closing the uptake damper to prevent too much cold air from rushing through and cooling the furnace and boiler plates too much. Then, with the hoe, he quickly draws the dead ashes and clinkers from one side of the furnace, and dropping the hoe for the slice bar, he sweeps the remaining fire over onto the clean grates and covers it lightly with fresh coal. He then shuts the door and opens the damper in the uptake.

By this time the other fires need attention, and he proceeds to trim them. First, he takes a small hoe or rake and pushes the coke that has formed at the front of the grates to the back going down the line and leveling all the working fires, one after the other. Then returning to the starting point, he shovels in four full scoops of coal on one side only. This will be the next fire to be cleaned, and he only wants to build up one side at this time. All the remaining doors receive four scoops each, and when the last one has received its portion, the first fire has burned up brightly on the clean side and is ready for more coal. He therefore proceeds to shovel in sixteen scoopsful and by the time this is burning in good shape, the dirty side is ready to clean. In a few minutes the first fire is clean and one side of the second one is nearly ready to receive the same treatment as the first. He proceeds in this manner with all the remaining fires, never showing any worry about the steam pressure. There is no occasion for worry, as the pressure has not varied five pounds since he shoved over the first half and started to burn down the fires. The water in the gage glass is practically at the same height, and he is as fresh as when he came on duty.

To sum up, neither "Strong Back" nor "Willing Worker" knows what he has to deal with or how to make the most of what he has to do with. "Strong Back" takes it easy and is inclined to be lazy. "Willing Worker" carries too light a fire and is after it all the time, shoveling, slicing and leveling over and over the whole day through. He knows the one rule for firing and is killing himself on a fairly easy job just because he hasn't enough confidence in himself to try a few experiments and find an easier method of doing the work and getting the same or better results.

In most plants the firemen have, as a rule, received but little instruction in their line of work, and not one in ten understands why he does certain things over and over again just because he has been told it was the thing to do. Look at the folly of loading the furnace full of green coal and expecting it to make steam; consider the combustible gases that go to waste up the chimney before that coal does any work; see the useless work and waste it causes. That is the lazy man's way. Then look at the result on the coal report. On the other hand, look at the holes that get into the light, level fire and also look at the unnecessary work caused by constant leveling and shoveling.

A proper fire is one that is heavy enough to prevent the cold air from drawing through the combustion chamber at the expense of operation, yet not too heavy. The grate should be practically covered with a live bright fire, hottest near the rear end, while all the coke and dead coal is at the front.

North Grafton, Mass. W. E. CHANDLER.

Disagrees with Some Observations on Lubrication

Referring to the article in the Nov. 29 issue, entitled "Some Observations on Lubrication" by K. Rankin, I quote the following extract: "The cheaper oils emulsify in the presence of water and become acid under the influences of air and heat."

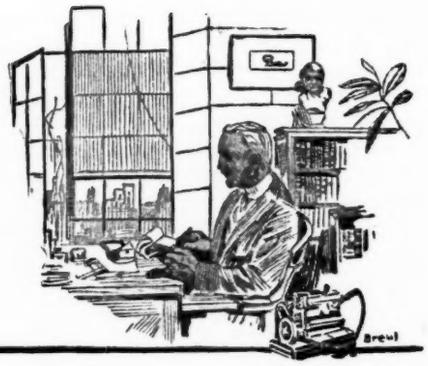
The first part of this is undoubtedly correct, since the cheaper oils generally lack the properties of the filtered and carefully treated oils which, being free from dirt, free carbon, tarry matter and other impurities tending to gum the oil when in use, separate from water and foreign material in the circulating system more quickly and completely.

However, concerning the part referring to oils becoming acid under the influences of air and heat, I would be most interested to learn more. Even the cheaper oils must come within rigid specifications on corrosion and acidity, and we may therefore assume that the new oil is free from acid of any sort within the range of all practical purposes. Also, we may assume that the oil is a straight mineral petroleum product, containing no animal or vegetable oil which might become oxidized and rank with the formation of certain fatty acids when subjected to the air and heat, since an oil thus compounded would never be knowingly used in a circulating system for the lubrication of machinery.

I am, therefore, at a loss to understand from what source this acid comes or what chemical action could take place in the system which would form any acid capable of making its presence known through either mechanical trouble or chemical analysis.

Charleston, W. Va. A. B. BOEHM

QUESTIONS AND ANSWERS



Longitudinal Shifting of Crankshaft

The crankshaft of our engine, which is a 300-hp. vertical Diesel oil engine, continually shifts lengthwise while the engine is in operation, the movement being about ½-in. What is the cause? R. H. G.

The trouble probably may be traced to a low bearing or to the shaft being set slightly inclined. As a result the shaft moves lengthwise in one direction with a screw effect. When the crank webs strike the bearing faces, the reaction, together with the pull of the connecting rods, causes the shaft to retreat to its first position, whereupon the action is repeated. You should check the alignment of the shaft.

Behavior of Fusible Plugs

Is it possible for a fusible plug to burn out with the water in the boiler above the plug? J. M.

A fusible plug that is covered with scale inside of the boiler can and commonly does melt and blow out when the water level in the boiler is above the plug, because the scale prevents the water from keeping the plug cool. On the other hand, soot or scale on the outside of the plug acts like a non-conductor of heat in protecting the plug from the heat of the fire and may prevent blowing out when the water level is below the plug.

To keep fusible plugs in efficient condition their surfaces, both on the fire and water sides, must often be scraped clean, but notwithstanding all precautions, they should not be regarded as reliable.

Front and Back Connections of Return-Tubular Boiler Settings

What should be the depth of front and back connections for return-tubular boilers? R. N. T.

For any size of boiler the back connection should have a depth of at least 24 in., to allow sufficient space for examination of the rear tube sheet and for expanding the tube ends. For boilers larger than 66 in. in diameter the back connections should be not less than 28 in. Greater depth is advantageous for obtaining better distribution of the heated gases to the lower tubes of the boiler. Front connections should be of a form and depth that will permit of an easy sweep of the gases to the uptake with cross-sectional area equal to the united cross-sectional areas of the flues.

Gaging Draft of Oil-Burning Furnace

The draft gage connected with the front end of the oil-burning furnace of our return-tubular boiler indicates as much draft as the gage that is connected at the foot of the stack. How can this be accounted for? F. I.

The draft gage connected with the furnace evidently is affected by the blast from the oil burner. If the opening of the connection with the draft gage is to one side of the burner, or the outlet placed just ahead of the burner is pointed "down steam," there will be an aspiration that may be indicated as draft, or pressure considerably below the actual pressure of the furnace gases. The draft pressure of the gases in an oil-burning furnace should be taken far enough beyond the burner to obtain fairly uniform readings when the open end of a draft-gage pipe connection is moved to different parts of the combustion chamber.

Heating Surface of Boiler

What would be the number of square feet of heating surface of a horizontal return-tubular boiler 72 in. in diameter and 14 ft. long, containing 127 three-inch tubes? J. J. F.

Allowing as heating surfaces, two-thirds of the shell, the internal area of the fire tubes and two-thirds of the area of the heads after deducting tube holes and taking all dimensions in inches, there would be:

In the shell:

	Heating Surface
Circumference = 72 in × 3.1416 = 226.195 in.	
⅓ of circumference = ⅓ of 226.195 = 150.796 in.	
Length 14 ft. × 12 = 168 in.	
Heating surface in shell = 150.796 × 168 in. = ...	25,333 sq. in.

In the tubes:

Internal diameter of 3 in tube = 2.782 in	
Internal circumference = 2,782 × 3,1416 = 8.740	
For 127 tubes 168 in. long, 8.74 × 127 × 168 = ...	186,476 sq. in.

In the heads:

Gross area of two-thirds of two heads = 72 × 72 × 0.7854 × 2 × ⅔ = 5,428 sq. in.	
Twice combined area of 127 three-inch tube holes = 2 × 127 × (3 × 3 × 0.7854) = 1,795 sq. in.	
5,428 — 1,795 = ...	3,633 sq. in.
Total Heating surface.....	215,442 sq. in.

or 215,442 ÷ 144 = 1,496.12 sq. ft.

Full-Load Current of an Induction Motor

A 40-hp., 500-volt induction motor has an efficiency of 0.90 and a power factor of 0.80. How much current is required at full load? Assume that the 40-hp. motor, which is fully loaded, is replaced by a 50-hp. motor, what would be the power factor of this motor? H. H. C.

If the motor is a three-phase machine, the current $I = \frac{Hp. \times 746}{E \times Eff. \times P.F. \times 1.732} = \frac{40 \times 746}{500 \times 0.90 \times 0.80 \times 1.732} = 47.9$ amperes. For two-phase the current $I = \frac{Hp. \times 7.46}{E \times Eff. \times P.F. \times 2} = \frac{40 \times 746}{500 \times 0.90 \times 0.80 \times 2} = 41.44$ amperes.

There is no way of calculating the power factor of the 50-hp. motor when loaded to 40 hp., but it should be somewhere between 0.70 and 0.75, provided its full-load power factor is only 0.80. The power factor of induction motors does not change very rapidly for loads above 75 per cent. It is down around 50 per cent load that the power factor begins to fall off rapidly.

Bagging of Boiler Shell from Nearness to Fire

Will bagging of a horizontal return-tubular boiler occur from having the grates too near the shell, if the boiler is clean of oil and scale? A. L. D.

Bagging rarely occurs in boilers made of modern steel plates kept entirely free from oil and scale. In most instances the failures have been due to want of homogeneity of the material rather than nearness to the fire. When boiler shells were made of puddled iron, the blistering and bagging of plates was of more common occurrence, including instances where the boilers were known to be perfectly clean. Overheating in such cases was clearly attributable to the presence of slag rolled into the boiler plates in the form of laminations that prevented the plates from being kept cool by the water of the boiler.

Changing Valve Setting from Non-Condensing to Condensing

What alterations of valve setting should be made in changing the operation of a single-eccentric Corliss engine from non-condensing to condensing? J. E. S.

The main purpose of operating condensing is to remove back pressure, thereby rendering the forward or working pressure more effective, because with part of the back pressure removed, the engine can perform more work when supplied with the same amount of steam or do the same useful work using less steam. From changing over to condensing with less back pressure, it may be necessary to close the exhaust valves earlier and thus secure sufficient compression of the lower pressure exhaust to make the engine run smoothly. To obtain earlier closure of the exhaust valves, advance the eccentric and give the steam valves more lap so they will not have too much lead from having advanced the eccentric.

Valve Setting from Friction Diagrams

After setting the valves of a re-erected 12 x 30-in. Green engine, guided by friction diagrams, we were disappointed to find that the valve setting gave unequal diagrams when the engine was loaded. How can good valve setting be obtained by making adjustments outside of regular running hours? R. G. T.

Friction diagrams cannot be relied upon for good valve setting except as rough approximations, because valve gears rarely if ever give the same equality of the cutoffs for different loads. The best that can be done is to take a number of diagrams when the engine is driving the regular load, determine their average and selecting that diagram of the set which measures nearest to the average, observe the character of adjustments required for its improvement. When the load goes off, take friction diagrams before making any alteration in the valve gear, and using these as a basis, adjust the valve gear to obtain in the friction diagrams the same kind of changes, but only one-half as much as needed for the desired improvement of the average load diagrams. Two or three such sets of diagrams and adjustments of the valve gear should be sufficient for obtaining as nearly the desired average-load diagrams as the engine is capable of making.

Advantages of Two-Stage Air Compression

What are the advantages of two-stage over single-stage air compression? W. R. T.

Two-stage compression consists in cooling the air after partial compression by the process known as intercooling, with the consequent reduction of volume of air required to be handled in the final compression. The advantages over single-stage compression are the saving of power, with more equable distribution of the load throughout the stroke of the compressor, thus greatly reducing the danger of centering and the opportunity of employing earlier cutoff in the steam cylinder, with better steam economy. Another advantage of multi-stage compression is the avoidance of high temperatures, permitting more satisfactory lubrication and less deposit of combustible matter in the air receiver and pipe lines with reduction of danger of fire and explosions. The multi-stage compressor also has a higher volumetric efficiency, since the terminal pressure is much lower than in the single-stage machine and the air confined in the clearance spaces, when expanded down to atmospheric pressure at the beginning of the intake stroke, occupies comparatively little space. The air delivered by a two-stage compressor is dryer than that furnished by a single cylinder. Under constant pressure the capacity of air to hold vapor decreases with its temperature, and during the passage of the air through the intercooler much of the original moisture in the air is precipitated. Consequently, less trouble is experienced from condensation in the discharge pipe, and the danger of freezing up the exhaust ports of machine using the compressed air is greatly reduced.

Air Required for Combustion of Coal

What is the formula for determining the quantity of air required for burning a pound of coal? J. N. S.

For approximate determination of the air required for theoretically complete combustion the following formula may be used:

$$Lb.\ of\ air = 12C + 35\left(H - \frac{O}{8}\right)$$

in which C, H and O represent the parts of a pound of carbon, hydrogen and oxygen, respectively, in a pound of the coal. As most fuels require between 11 and 12 lb. of air per pound of fuel, it is usual to consider that 12 lb. of air will be required per pound of coal. But it is necessary to admit more air into the furnace than is actually required to burn the coal in order to insure that each atom of carbon will meet an abundance of oxygen. This excess air sometimes is called air of dilution because it dilutes the gases rising from the fire and mingles with them, giving each atom of carbon an opportunity to unite with enough oxygen for complete combustion. The amount of excess air depends on the draft; the weaker the draft the more air of dilution will be required. It is usual to supply twice as much air as actually required for theoretically complete combustion when natural draft is used, and one and one-half times as much when forced draft is used. The excess air is then 100 per cent for chimney draft and 50 per cent for forced draft.

A pound of air at the temperature of 62 deg. F. has a volume of 13.14 cu.ft. and therefore to effect complete combustion with natural draft it may be assumed that for each pound of coal fired there should be sufficient draft to supply about $12 \times 2 \times 13.14 = 315$ cu.ft. of air and with forced draft about $12 \times 1\frac{1}{2} \times 13.14 = 236$ cu.ft. of air.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

Pulverized Coal Discussed by A.S.M.E.

AT a meeting in Bayonne, N. J., on the evening of Dec. 16, 1921, the Metropolitan Section of the A.S.M.E. held a symposium on the subject "Pulverized Coal for Boilers from the Operator's Standpoint." Abstracts of four of the papers read at this meeting follow:

Puget Sound Power and Light Company

BY W. J. SANTMEYER

This paper deals with the pulverized-coal installation at the Western Avenue steam-heating plant of the Puget Sound Power and Light Co. In 1916 the writer became interested in pulverized coal because of an advance in the price of the fuel oil that was then being used. It was thought that pulverized fuel might overcome the difficulties that were being encountered with the poor coal found in the Washington fields.

After successful preliminary experiments with one boiler, arrangements were made to equip for powdered fuel the entire plant of ten boilers, with a total heating surface of 41,000 sq.ft., and at the same time to install a complete drying and pulverizing plant. So little was known of the art at that time that considerable experimenting was necessary. It was finally decided that vertical firing was not practical with the given equipment. This was partly due to the fact that too little depth was available for furnaces under the boilers and partly to the trouble experienced in maintaining arches over the dutch ovens which are necessary for the installation of the vertical burners. Consequently, all the boilers were equipped with horizontal burners and the dutch ovens were eliminated.

As the furnaces were finally constructed, the following combustion volumes per square foot of heating surface were obtained: 0.2 cu.ft. under four 3,000-sq.ft. boilers and three 4,000-sq.ft. boilers; 0.3 cu.ft. under one 5,000-sq.ft. boiler and one 6,000-sq.ft. boiler, 0.45-cu.ft. under one 6,000 sq.ft. boiler.

Although the plant is close to the business center of the city, there have been no complaints regarding ash. This is doubtless due to the high flame temperature maintained. The ash found in the rear connections and breechings of the boilers is very fine and is handled by sluicing, whereas the ash and slag from the furnaces is raked out and handled in a small dump car.

In the drying and pulverizing plant there are two driers, indirectly fired with pulverized coal. Dust is removed by the combination of a "cyclone" and a washer whose sprays are supplied with salt water from Puget Sound. That the plant is an exceptionally clean one, is indicated by the fact that it was painted white a year ago and still remains white.

The coal used is a refuse that had accumulated at the company mine for twenty years. It is very fine in size, practically all of it passing a 20-mesh screen. About 190,000 tons of this coal has already been burned, with an average boiler efficiency of 80 per cent. At the same time it has been possible to develop very high boiler ratings. The actual operating cost of the fuel-preparing plant, not including overhead costs of taxes, interest, depreciation, etc., is about 71 cents per ton, as indicated by the following table:

	Per ton	
MAINTENANCE		
Driers	$0.014	
Mills	0.038	
Miscellaneous equipment	0.023	
Total maintenance	0.075	
OPERATION		
Labor	$0.312	
Power (estimated at 1 cent per k.w. hour)	0.260	
Fuel	0.060	
Total operation	0.632	
Total maintenance and operation		$0.707

It should be noted that these figures were obtained when labor was at its peak. The cost of labor and power for pulverizing would ordinarily be less.

Over-all efficiencies, on the basis of pulverized coal averaging approximately 9300 B.t.u. per pound, range from 77 to 81 per cent. This figure represents operating conditions, with the firing up of from two to five cold boilers every day.

United Verde Extension Mining Co.

BY H. L. KOHLBERG

This copper-smelting plant is located in the northern part of Arizona in the Verde River valley, near the town of Jerome. In 1917, on account of the increasing cost of fuel oil, the reverberatory furnaces as well as the boilers were equipped for powdered coal. At the present time the plant is shut down, the same being true of all copper smelters west of the Mississippi River.

The coal used comes from Gallup, N. M., and contains about 14 per cent moisture and 7 per cent ash, and has a calorific value of 11,000 B.t.u. The plant has two direct-fired Stirling-type boilers with 4,390 sq.ft. of heating surface per boiler. They are equipped with superheaters, but not with economizers. When operating at rated loads, each boiler requires about 15 tons of powdered coal per day. The reverberatory furnaces require from 80 to 100 tons of coal per day.

Some of the main features of the fuel-preparing plant are as follows: A 24 in. single-roll crusher reduces the run-of-mine coal to 1-in. cubes or less, any tramp iron being first removed by the magnetic head pulley of the conveyor that feeds the crusher. The crusher delivers into a 16-in. screw conveyor, which brings the coal to the drying and pulverizing plant proper. Here an elevator lifts it to a bin, from which it is fed into an indirect-fired, rotary drier of 20 tons per hour capacity. This drier is fired with powdered coal and is designed to reduce the moisture in the coal from 14 per cent to about 3 per cent.

After leaving the drier, the dry coal passes a disc magnet, which removes any remaining iron or steel. It is then conveyed into bins above four 42-in. pulverizing mills, each of which is driven by a 75-hp. motor. In these mills the coal is ground to a powder and is lifted by the air current induced by a fan wheel built into the mill. It is then blown through a circular screen to the discharge spout. The air accompanying the coal passes out through a sheet-iron housing and stack. The bottom of this housing is formed by a screw conveyor, into which the pulverized coal drops from the mill discharge. This conveyor brings the coal to an elevator which feeds it into other screw conveyors and distributes it to the bins located at the furnaces and boilers.

When the fuel-preparing plant first started to operate, it was noticed that black clouds of coal dust escaped through the stack that carried off the surplus air from the pulverizing mills. This was overcome by connecting the mill exhaust stack to the suction of the fan that blows the powdered fuel into the drier furnace. This not only eliminated the dust, but effected a noticeable saving in the fuel required for the drier.

About 50 cu.ft. per pound of coal is the amount of air required to carry the powdered fuel through the furnace pipe into the furnaces. This is less than one-third the amount required for combustion. The remaining two-thirds enters through adjustable portholes.

The waste-heat boilers, built to receive the waste gases from the reverberatory furnaces, absorb from 40 to 50 per cent of the heat in the coal fired. When 93 tons of coal was burned in the furnace per 24 hours, the evaporation in the waste-heat boilers was 4.56 lb. of water per pound of coal, with a steam pressure of 185 lb. gage and a steam temperature of 540 deg. F.

In designing the settings of the waste-heat boilers, it was necessary to take into careful consideration the question of ash deposit in the flue. For instance, long horizontal connections, particularly when of small cross-section, gave trouble by accumulating a deposit of fused dust and ashes. This trouble was corrected by using vertical or sloping passages and by making them short and of ample cross-section.

The operation of the powdered-coal-fired boilers was satisfactory. In one six-day test an average efficiency of 79.5 per cent was secured.

Power Station of M. K. & T. Ry.

By W. H. Maddocks

During the year 1913 the price of fuel oil and natural gas was investigated in the power plant of the Missouri, Kansas & Texas Ry., operating shops and terminals at Parsons, Kan. Investigation showed a decided increase in cost of fuel with possible further increases. The plant was only 25 miles from a large coal deposit close to the line of the M. K. & T. Ry., but the boiler plant was not adapted to burn coal on grates or stokers without extensive alterations. In the spring of 1913 it was decided to use pulverized coal, but the equipment was not put into operation until 1916.

In the original arrangement the boiler plant consisted of eight horizontal water-tube boilers, each having 2,500 sq.ft. of heating surface. The boilers carried 150 lb. pressure with no superheat and were set in four batteries of two boilers each. Each battery was fitted with a steel stack 5 ft. in diameter and 60 ft. high. The boilers were set 7 ft. from the floor to the flue line and were provided with horizontal baffles and furnaces especially designed for burning oil and gas. Two of the boilers were operated for forty days without any changes, but it was discovered that good efficiency could not be maintained without increasing the furnace capacity, removing the horizontal baffles and using a brick wall in combination with a vertically baffled boiler, making a three-pass travel for the gases. These changes were found to be necessary on account of the density of the ash from Kansas coal, which accumulated on the top of the baffles. The two boilers mentioned were therefore kept on oil service, while the necessary changes were made in the other boilers, including the addition of dutch ovens.

After some experience with these settings, it seemed desirable to make further changes. For instance, the furnace capacity was increased from 750-cu.ft. to 1,300 cu.ft., which made it possible to carry 200 per cent rating for any desired length of time. Other minor changes were also found to be necessary.

The gas and oil burners were left available in these furnaces to meet interruption of service so that these fuels could also be used jointly with pulverized coal. This flexibility was one of the deciding factors in adopting pulverized coal. As a result it was possible at several times to take advantage of fluctuations in the relative price of gas, oil and coal, and burn the fuel that was cheapest at the given time.

In regard to furnaces and brick work, repairs to bridge walls were required about every six months at the start, but after changing burners and furnaces as previously stated, the walls became coated with an armor of fused material, so that nine months' operation showed no apparent depreciation.

From our experience we conclude, (1) that pulverized coal can be used with maximum flexibility and reliability; (2) that repairs to preparation machinery, due to their rugged construction, are not excessive; (3) that correctly designed furnaces are easily maintained at high ratings and high efficiency; (4) that low grades of coal can be successfully burned.

The Application of Powdered Coal to Existing Plants

By H. D. Savage

The statement is frequently encountered that it is probably a good proposition to apply pulverized fuel to a new plant, but hardly worth considering for existing plants. This idea seems to be at variance with the facts, since there are many installations that have been made in existing plants with decided profit to the owners.

Powdered-coal installations are so flexible in their application as to make it generally possible to apply the system with but slight changes in the existing conditions. This is especially true, since it has been thoroughly proved that it is not in all cases necessary to dry the coal before burning. In fact, in burning eastern coals, it is not necessary in any case to use driers. This immediately does away with one of the most serious problems and with one of the largest items of expense. It also warrants the placing of powdered-coal installations in much smaller plants than would otherwise be possible.

This statement is based on considerable study and on installations that have been operating on undried coal for practically four years. The Allegheny Steel Co. has been successfully operating with powdered coal for nearly four years, no driers having been installed in this plant. Likewise, the Ford Motor Co. has been operating for about a year with no driers.

The following table shows the result of a test made with powdered coal on Boiler No. 8, Lakeside Station of the Milwaukee Electric Railway and Light Company.

	—Per cent of rating developed—		—Per Cent of Heat Absorbed—	
Test No.	Boiler and Superheater	Boiler Superheater and Economizer	Boiler and Superheater	Boiler, Superheater and Economizer
14	130	136	84.5	88.3
15	136	143	84.7	88.8
4	144	151	85.4	89.1
22	167	175	86.1	90.3
8	176	185	85.1	89.5
9	205	216	83.9	88.4
17	238	253	82.2	87.5
19	256	270	82.8	87.6

The results of these tests show that ratings from 130 to 256 per cent were obtained with a variation in efficiency of only 4 per cent.

Western Engineers Discuss Electricity in Steel Mills

At a recent joint meeting of the Western Society of Engineers, the Association of Iron and Steel Electrical Engineers and the Chicago sections of the A.I.E.E. and the A.S.M.E., an interesting paper on the application of electricity in steel mills was presented by W. S. Hall.

He held that, of the fuels available from the manufacturing plant, coke oven gas and blast furnace gas are in the greatest quantities, although there are limited quantities of coke braize, and waste heat boilers may be installed to use the waste heat from the open-hearth furnaces. All these sources of heat and fuel, however, are intermittent, so that a high-pressure steam plant using coal-fired boilers is usually installed to insure continuity of service. The problem is to balance the power demand as nearly as possible with the supply of waste heat or fuel available, and so adjust one to the other that there will be a continuous balance, this being necessary because of the intermittent flow and the impossibility of economically storing gas of such low heat value. This very question, said Mr. Hall, has been the biggest single problem in the steel industry; another problem has been introduced by the general tendency toward the adoption of 60-cycle power equipment in preference to the 25-cycle apparatus used in nearly all of the old-time plants.

In regard to transmission, the speaker pointed out that each installation must be worked out separately and with a view toward future expansion, but in a new, large, plant many of the difficulties arising from the use of the overhead system might be eliminated by placing the cables underground, even though the first cost of such an installation is greater. Voltages vary according to the peculiar conditions existing at the mills, but for large motor drives, around 2,200 volts is usual. As many of the engine-driven rolling mills are being replaced by motor drive, according to the speaker, continuity of the power service is of increasing importance and the loss of power more costly than ever before.

In a short discussion following the paper, Gordon Fox referred to the diversity factor on a group of blast furnaces tending to make the flow of gas more uniform. On the average, a 600-ton blast furnace produces enough gas to generate 3,500 kw., and on the peak supply of gas it is possible temporarily to generate 5,000 kw. The usual voltages for direct-current cranes range from 220 to 250 volts, while the smaller alternating-current wound-rotor motors generally operate on 220 volts.

Secretary Merrill Speaks on Colorado River Project

The tremendous size and importance of the Colorado River power and irrigation project were well brought out in a recent speech by O. C. Merrill, executive secretary of the Federal Power Commission, before the League of the Southwest at Riverside, Cal. While not committing himself to the idea of government ownership for the project, or even single ownership, he insisted upon a centralized control that would make for the best possible use of the river. He regarded irrigation as the more important function of the river, but on the other hand felt that there would ultimately be a demand for a large amount of power in that district, and that provision for developing it should be decided upon now. His whole idea was to go at the work in a large way, deciding in the first place upon a comprehensive and definite plan for the complete utilization of the river for both irrigation and power purposes. He pictured clearly the magnitude of the project in the following words:

In its length of 1,700 miles the Colorado extends from the permanent snowfields of the Rocky Mountains to the subtropical lands of the Imperial Valley. Within its basin are five million acres of irrigable land. The volume of its waters is exceeded only by the Sacramento, the Columbia and the Mississippi. Along its course it would be possible to develop more than 6,000,000 water horsepower—two-thirds as much as is developed in the entire United States today. The problems of the Colorado affect seven of the states of the United States and two of the states of Mexico.

In discussing the project further, he divided the river into three parts: The upper section, from the head-waters to the mouth of the San Juan, having power possibilities of about 2,000,000 hp.; the middle section, from the mouth of the San Juan to the mouth of the Williams, having possibilities of about 4,000,000 hp.; the lower section, from the mouth of the Williams to the Gulf, having relatively unimportant power possibilities. He felt that the upper section could well be used for either irrigation or power, that the middle part should be used almost entirely for power development and that the lower section should be devoted primarily, if not exclusively, to irrigation.

He regarded the most promising future source of demand for Colorado River power as being the Southern half of California, where the continued depletion of the state oil reserve and the increasing industrial and agricultural development will before long bring the necessity of new sources of power outside the boundaries of the state.

The development of power in the basin of the Colorado for use outside, said Mr. Merrill, will be an advantage, not a disadvantage, to the people and the industries within the basin. He pointed out that the power demands near the river are not large enough to justify extensive development, so that cheap power would probably not be made available in that district if it were not possible to transmit it over long distances to greater sources of demand. An interesting prophecy was his statement:

I do not believe I am indulging in undue romancing when I say that I expect to see at no far distant date power developments along the Colorado River forming the connecting links between the transmission systems of southern California and those of Colorado and of northern Utah. The distances are no greater than those through which interconnection has already been effected in California.

Leather Belting—What Is, and What Is Not Known About It*

Technical research for manufacturing industries has grown at an enormous rate within the last decade or two, and competent men, capable of investigating technical problems in an original way, have been in greater demand than in former times. This growth is due to the fact that experience has shown the value of the results obtained by such methods.

The use of leather belting for power transmission has been common for many years, but until very recent times comparatively little had been done in the way of a scientific investigation of the subject. The problems involved are difficult, so it would pay the manufacturers to begin at the bottom and make a thorough study of every question involved in the manufacture and use of this product.

The experienced belt maker would probably say that the most frequent troubles are due to belts stretching or running crooked. The latter ordinarily occurs with high-speed drives where single belts are used. The stretch of a belt depends on a number of things, such as the kind of hide used, tannage, method of currying (that is the percentage and distribution of grease in the leather itself) and the thoroughness of the stretching given to the leather before it is made into belts. While a moderate amount of stretch is, perhaps, not a serious matter, it is important that this be removed as soon as posible so that an effective tension, high enough to carry the load satisfactorily, may be maintained. It would not be surprising to see higher tensions adopted as methods of manufacture and types of bearings are improved.

Closely allied with the question of stretch are those of "creep" and elasticity. Recent experiments have shown that the leather belt is not perfectly elastic, since it does not come back to its original length immediately after the tension is removed. This will account for some of the slip that always occurs.

The large difference between the observed coefficient of friction on a new belt, and that obtained after it has been in use for some time, shows clearly the importance of a proper finish on the surface. Recent experiments have shown that the coefficient of friction also varies materially for different speeds of slip, but does not vary much with the tension of the belt. The power that may be transmitted depends on three factors—the tension in the belt, the coefficient of friction and the speed of the belt.

There is a wide difference of opinion on the question of speed. Velocities as high as 9,000 ft. per min. have been considered permissible, but most manufacturers would not agree with this figure. In fact, data presented by Dr. E. D. Wilson seems to show that a double belt at that speed would transmit practically no power at all. There is no available machinery for making actual tests at these high speeds, but other considerations seem to indicate that the greatest efficiency would be obtained at speeds of 4,000 to 5,000 ft. per min. We know, of course, that centrifugal force increases very rapidly at higher speeds, tending to throw the belt away from the pulleys.

It has recently been shown conclusively that the grain side of the leather belt is, on the average, decidedly superior to the flesh side as a contact surface, although there are occasional exceptions to this rule.

There are many other branches of the subject about which we have a partial or hazy idea. These include the effect of pliability and the effect of the relative diameters, location, etc., of the pulleys. It is to be expected that great benefits will accrue to the manufacturers of leather belting and also to the public, if the manufacturers will enter into a scheme of intensive research to accumulate definite information on these doubtful points.

*Abstract of paper by J. Edgar Rhoads, read before the National Association of Leather Belting Manufacturers (Philadelphia) Nov. 16, 1921.

The Value of Our Coal

A good idea of the size of Uncle Sam's coal bin and the wealth represented by its contents is given by Secretary of the Interior Fall in the annual report of his department.

In the United States proper he estimates that there are government holdings of ten billion tons of bituminous coal, which at a royalty of 10 cents a ton would yield the government a billion dollars; thirty billion tons of sub-bituminous coal, from which an 8-cent royalty totaling $2,400,000,000 is estimated; and fifty billion tons of lignite, on which a royalty of 5 cents, or a total of 2½ billion dollars, is estimated. He says these calculations do not include coal on railroad lands, on private grounds and on private lands in the public-land states not developed. He also estimates that the Government holds in Alaska twenty billion tons of coal of all grades on which he estimates a 5-cent royalty, or a total of one billion dollars. Total coal royalties in the United States are estimated at $5,900,000,000 and in Alaska of one billion dollars.

News in the Field of Power

Hoover Put in Charge of Colorado River Project

Herbert Hoover has been appointed by President Harding as Federal Chairman of the Colorado River Commission recently created jointly by Congress and the Southern States bordering the river. The governors of these states approved the appointment.

It is the duty of this commission to work out a comprehensive plan for the development of the entire river and to make recommendations to Congress. This will involve the difficult task of deciding upon the conflicting claims of the states concerned with the project. Another problem to be decided is the question as to whether the work shall be done by the Government or by private concerns and municipalities.

New Hydro Plant on Little Red River, Arkansas

About 6 miles above Judsonia, Ark., on the Little Red River, work has been started on a hydro-electric plant that will have an ultimate capacity of 20,000 kw. in four 5,000-kw. units. The date set for completion of the plant, with three units installed, is July 1, 1922. The first cofferdam has been constructed, and excavation is now going on for the draft tubes.

The waterwheels will be of the reaction type, operating under a head of 70 ft. The contract has not been awarded for either the turbines or the generators, but the specifications will call for 6,600 volts, three-phase, 60-cycles. The current will be transmitted at a voltage of 110,000.

The work is being done for the Arkansas Hydro-Electric Development Co. by J. Livingston & Co., of New York City. The engineers are J. E. Sirrine & Co., of Greenville, S. C., and Dickinson & Watkins, of Little Rock, Ark.

Mitchell Dam Dedicated

The Alabama Power Co.'s new dam, on the Coosa River, about 50 miles southeast of Birmingham, was dedicated recently in the presence of several hundred people who came from Birmingham, Montgomery and other sections of Alabama on two special trains.

The dam was named in honor of the late James Mitchell, who was president of the Alabama Power Company for many years. Thomas M. Martin, the new president of the company, and several of his associates, made speeches at the dedication services and headed the large party of Alabama people who visited the dam.

The excavating for Mitchell dam is about completed, and on the occasion of the dedication the first cement was poured. The structure is to be 1,115 ft. long, 70 ft. high and 74 ft. wide at the base, and will have a capacity of 100,000 hp., costing about $8,000,000.

At this time 2,000 men are at work and it is estimated that the job will be done by the spring of 1923.

Mitchell dam is 15 miles below the dam at Lock 12, where the power company already has a 120,000-hp. plant. The power plant to be installed at the new dam will be equipped with four Westinghouse generators driven by Allis-Chalmers water turbines, with a capacity of 24,000-hp. each, making 96,000-hp. at the low stage and 108,000 hp. at the flood stage.

It is the intention of the Alabama Power Co. to construct two other dams on the Coosa River at an early date, it is announced. When this is done, it will not only add more power, but it will make the Coosa River navigable the year round from Rome, Ga., to the Gulf of Mexico, a distance of 850 miles.

Catalogs as Textbooks

MANY would be surprised to know the brains and experience represented in catalogs of power-plant apparatus. The old-fashioned "seed catalog" type has given way to practical, useful booklets that explain the construction and operation of all kinds of apparatus clearly and simply.

Newly published catalogs and bulletins are announced in Power's "Trade Catalogs" column. No reader should feel hesitancy in writing for them, whether he is in a position to buy or not. The modern business man is not penny wise and pound foolish. He is glad to put his literature in the hands of anyone having a legitimate interest in it, because he realizes the value of having his products better known and understood.

Prospective buyers send for catalogs as a matter of course, but many others secure them simply for the information they contain, and find them first-class textbooks.

McGraw-Hill Co. Launching a New Paper

Bus Transportation is the name of a new monthly journal to be published by the McGraw-Hill Company, beginning this month. It is to be an extension of the service of the *Electric Railway Journal* and is to be handled by the same staff with the addition of some new men from the field. The paper will come out about the middle of each month. Its purpose has been stated by Mr. McGraw, president of the company, as follows:

The mission of this paper is to stabilize and develop bus transportation wherever and whenever it contributes to the welfare of the community; and to aid in the co-ordination of all passenger transportation agencies.

Queenston-Chippawa Development Officially Opened

The Queenston-Chippawa plant of the Hydro-Electric Power Commission of Ontario was officially opened on Dec. 28, 1921. This plant, instead of using the water at Niagara Falls, is supplied through a canal 12 miles long running from the Chippawa River, about 4 miles above the Falls to Queenston, at the lower end of the Gorge. This has made possible a head of 305 ft., instead of about 215 ft., the highest obtainable at the Falls. Some of the earlier plants at the Falls are operating under a head of only 140 ft. Utilizing the water under a 305-ft. head makes possible obtaining about 30 hp. per cubic-foot-second against a maximum of 22 at the Falls. The Queenston plant has been laid out for an ultimate capacity of 500,000 hp. in nine 45,000-kva. units, five of which are now on order or being installed.

Imlay and Flood To Talk on Superpower at Washington

The Superpower report will be authoritatively discussed at a joint meeting of the Washington sections of the A.I.E.E. and the A.S.M.E. at 8 p.m., Jan. 10, in the auditorium of the Department of Interior Building.

The speakers will be L. E. Imlay, consulting engineer with the Niagara Falls Power Co., and Henry Flood, Jr., who was engineer-secretary of the Superpower Survey. Both have expressed their intention of departing somewhat from the published report.

N. W. Storer, general manager of the Westinghouse company, will probably discuss the report from the viewpoint of electrification of trunk-line railways, and other important discussion is expected.

New York Now Licensing Engineers

Actual operation of the Engineers' License Law that was passed in New York State last May began recently, when the board of five examiners met at Albany and considered the list of 241 applicants, of whom 171 were passed.

The Board of Examiners is broadly representative of the various branches of engineering, as may be seen from the following list of its members: President, Albert H. Hooker (Chemical Engineering), of Niagara Falls; vice-president, Major Percy E. Barbour (mining engineering), of New York City; secretary, Henry G. Reist (electrical engineering), of Schenectady; Virgil M. Palmer (mechanical engineering), of Rochester; and Col. Walter G. Eliot (civil engineering), of New York.

The movement for licensing professional engineers is spreading over the country, and has resulted in the passage of legislation along the same general lines as the New York law in a number of different states. It is even said that the question has been agitated in 40 of the 48 states. There will naturally be a conflict between the provisions of the various laws, and so an effort is being made, particularly by American Engineering Council, to secure uniformity in this legislation. The Council is opposed to the licensing of engineers, but feels that if there must be such laws, they will be less objectionable if they are uniform, so that an engineer licensed in one state may practice elsewhere without trouble.

"Why no Action on Muscle Shoals" Asked in Washington

Members of the military affairs committee of the House of Representatives are said to be showing increasing restlessness as a result of the delays in submitting Henry Ford's Muscle Shoals proposition to Congress. They point out that the matter still hangs fire, although six months have passed since Mr. Ford made his offer, and no other offer that is regarded seriously has been submitted. Representative Kahn, the chairman of the committee, is understood to have requested members to be patient a little longer, as he has assurances from the Secretary of War that the matter is soon to be laid before the committee. Those who think favorably of the Ford proposition are asking why so much time is given to offers that are obviously not entitled to serious consideration.

It has been rumored that the Construction Company of North America, which is driving the Hetch Hetchy tunnel, has submitted a better offer than Mr. Ford's, but up to a late date no such offer has been officially received.

Perpetual Motion Almost Achieved

Philadelphia, the home of perpetual motion, already made famous by the Carroll CO_2 machine and the Keeley motor, has again been pushed into the limelight by D. W. Kolvin, who has invented a spring motor that is described as a self-increasing horsepower machine. He modestly refrains, however, from claiming the discovery of perpetual motion; it is not known how near he has come to that ideal, but the device ran for about three minutes in a test before a jury that was trying him on a charge of using the mails to defraud.

Mr. Kolvin is described as a gray-haired, spectacled man, with the slight stoop of the student. He has apparently lost no confidence in his spring motor since his imprisonment in June, 1921. He testified during his trial that he had been offered $2,000,000 for his invention "if it proved practical." He is accused of having gathered in about $21,000 in Hagerstown, Md., and is said to have gotten several hundred thousand dollars through the mails. He said that he had been in the coal business in Cleveland and sold out for $40,000, which he sunk in his experiments. He admitted having received the $21,000, but showed himself a thoughtful, considerate man by saying that he "had in mind returning the money."

Princeton Lectures Announced

A series of lectures on engineering subjects by speakers of more than ordinary prominence has been announced by Princeton University. They are to be held in the evening under the auspices of the Cyrus Fogg Brackett lectureships at the University at Princeton, N. J., and will be open to the public. The schedule of lectures follows:

Jan. 10. "Public Policy and Industrial Relations," by Joseph B. McCall, president of the Philadelphia Electric Company.

Feb. 21. "Leonardo da Vinci—Artist, Natural Philosopher, Engineer," John W. Lieb, vice-president of the New York Edison Co.

March 15. "Influence of the Executive Upon Engineering Practice of the Public Utility," by Charles L. Edgar, president of the Edison Electric Illuminating Co. of Brooklyn.

April 4. "Pacific Coast Public Utility Development," by John A. Britton, vice-president of the Pacific Gas & Electric Company.

April 25. "The Petroleum Industry," by Dr. N. E. Loomis, director, Experimental Division of Development, Standard Oil Co. of New York.

May 9. "Some of the Personal Problems of a Graduate Engineer," by Col. W. C. Spruance, '94, vice-president of E. I. du Pont de Nemours Corporation.

Lignite as a Coal Substitute

Lignite is often spoken of as a possible substitute for anthracite and bituminous coal, so that some have doubtlses been led to expect it to replace coal to a large extent. While it is impossible to predict what the far distant future may bring, it is certain that lignite cannot successfully compete with coal on a commercial basis for a long time. This was emphasized not long ago in a report to the Bureau of Mines by Prof. Erich W. Zimmerman, who stated that there is no chance for the early development of lignite in the Northwestern States except as a domestic fuel.

Although the report stresses the great importance of the railroad situation in considering problems of fuel supply, it points out that the brown lignite available to the Northwest is found only in the western section of the Dakotas, especially North Dakota. It is therefore as far away from the centers of demand for most of that part of the country, as is the bituminous coal of Illinois and Iowa. Only with a narrow zone, between Bismarck, N. D., and Miles City, Mont., is there a notable geographical advantage for the lignite.

However, lignite has such a low heat value that even at one-half the price per ton of bituminous coal, it costs as much per heat unit, and is therefore even more expensive per thousand pounds of steam generated. Lignite would have a chance to compete with other coals if the price dropped to about one-third that of Youghiogheny or Elkhorn coal, but such a price ratio is not likely to prevail over any wide range of territory.

The report states that very little may be expected in the way of by-products from the retorting of lignite. It has been well established that briquets can be made of most satisfactory quality, but the commercial features of the process are still to be investigated. The Bureau of Mines is studying the whole lignite problem, in spite of the fact that the market is probably severely limited; while it is not expected that briquets will enter the industrial field, it is felt that they will help to fill part of the domestic demand for the territory in which lignite is found.

Chile To Have New 30,000-hp. Hydro Plant

The United States Department of Commerce has received information that the so-called Maitenes Concession, consisting of a 30,000-hp. Hydro-Electric Plant on the Maipo and Colorado Rivers, supplying the Chilean cities of Santiago and Valparaiso, is to be developed promptly. Electricity will be produced at 6,600 volts, 50 cycles, three-phase, and will be stepped up to 110,000 volts for transmission. Provision will be made for a possible second generating unit.

War Department To List Power Resources

Plans are being made by the War Department in co-operation with the National Electric Light Association to set up the necessary organization for taking a continuous inventory of power resources, developed and undeveloped, in the United States. The plan is in the nature of a preparedness measure, as the Government wishes to have on hand complete data as to available power in case of war. It is the intention of the War Department to co-operate with the industry in securing this information, rather than to make an extensive survey of its own.

An insulating material known as Xilite has been developed in Italy, according to information received by the Department of Commerce. It is described as a resin resulting from a chemical synthesis, and is said to be an ideal substance for insulating wire and other electrical apparatus. It is already being manufactured on a large scale in Venice. The product is a result of the great hydro-electric activity in northern Italy.

Personals

E. W. Rice, Jr., president of the General Electric Co., has been elected to honorary membership in Tau Beta Pi, a national honorary engineering society that was founded at Lehigh University. The basis of honorary membership is distinguished attainment in the engineering profession. Mr. Rice was initiated Dec. 17, by the Schenectady (N. Y.) Alumni Association of the society, at a meeting attended by 65 local members and followed by a dinner.

Society Affairs

Coming Conventions

American Society of Civil Engineers—Annual meeting at New York City Jan. 18-20. Secy., Elbert M. Chandler, 29 West 39th St., New York City.

American Institute of Electrical Engineers—Midwinter convention at New York City, Feb. 15-17. Secy., F. L. Hutchinson, 29 West 39th St., New York City.

American Society of Mechanical Engineers — Spring meeting at Atlanta, Ga., May 8-11. Secy., Calvin W. Rice, 29 West 39th St., New York City.

Waterbury Section, A.S.M.E., will meet Jan. 10 for a talk by John Robson on "The Waterbury Hydraulic Variable Speed Gear."

The Providence Engineering Society will meet Jan. 10 for a lecture on "Drawing as a Part of Engineering Education—Layout and Equipment of the Drafting Room," by Prof. Walter H. James, of the Massachusetts Institute of Technology.

Baltimore Section, A.S.M.E., will meet Jan. 11 for two papers, by H. D. Savage and John Van Brunt, both of the Combustion Engineering Corporation, entitled "Powdered Coal Application to Central Power and Heating Stations" and "Some Notes on the Construction and Performance of the Coxe Stoker."

Business Items

The Wilson Welder and Metals Co., Inc., has moved its offices and factory to 132 King St., New York City.

The Combustion Engineering Corporation has opened a new branch office at 806 First National Bank Building, Pittsburgh, Pa., in charge of W. C. Stripe, formerly manager of the Philadelphia office.

The Ideal Commutator Dresser Co. 3229-31 Sheffield Ave., Chicago, manufacturer of the Ideal commutator resurfacer, has announced the establishment of district sales offices in New York City at Tribune Building, 154 Nassau St. R. W. Becker is in charge.

The American Palestine Co., 874 Broadway, New York City, is arranging a permanent exhibit in Palestine of American machinery and products, and is trying to create a market for American goods in that country. The company is offering to help considerably in the way of shipping and demonstrating the exhibits.

Trade Catalogs

Steam Purifiers—Andrews-Bradshaw Co., B. F. Jones Bldg., Pittsburgh, Pa., Eastern selling agent for the Tracy Engineering Co. Catalog No. 13, discussing the general principles of steam separators and the necessity for the elimination of moisture in steam, and describing the Tracy steam purifier, which is guaranteed to secure 100 per cent dry steam.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Dec. 19, 1921	Dec. 26, 1921
Pool 1,	New York	$3.00	$2.90@3.20
Pocahontas,	Columbus	2.15	2.10@2.25
Clearfield,	Boston	1.80	1.30@2.35
Somerset,	Boston	1.85	1.60@2.00
Pittsburgh,	Pittsburgh	2.15	2.10@2.20
Kanawha,	Columbus	1.80	1.80@2.00
Hocking,	Columbus	1.90	1.90@2.00
Pittsburgh No. 8	Cleveland	2.00	1.90@2.00
Franklin, Ill.,	Chicago	2.90	2.75@3.00
Central, Ill.,	Chicago	2.50	2.25@2.75
Ind. 4th Vein,	Chicago	2.75	2.40@3.00
Standard,	St. Louis	1.90	1.90
West Ky.,	Louisville	1.75	1.50@2.00
Big Seam,	Birmingham	2.10	1.90@2.30
S. E. Ky.,	Louisville	1.70	1.40@1.60

New York—On Dec. 29 Port Arthur light oil 22@25 deg. Baumé 5c. per gal. 30@35 deg., 6c. per gal., f.o.b. Bayonne, N. J.

Chicago—Dec. 21, for 24@28 deg. Baumé, 80@85c. per bbl.; 32@36 deg., 2¾@3c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Dec. 13, f.o.b. refinery, Pennsylvania, 36@40 deg., 5@5¼c. Oklahoma, 24@30 deg., 95c. per bbl.; gas oil, 32@34 deg., 2½@2¾c. per gal.; 34@36 deg., 3¼c., 38@40 deg., 3½c. per gal.

St. Louis—Dec. 10 prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 80c. per bbl.; 26@28 deg., 90c.; 28@30 deg., $1; 32@34 deg., 2¼c. per gal.

Philadelphia—On Dec. 21, 26@28 deg. Baumé, Oklahoma, 80@85c. per bbl.; 30@34 deg., Oklahoma (group 3), 2½@2¾c. per gal.; 16@20 deg., Seaboard, $1.15@$1.25 per bbl.

Cincinnati—Dec. 21, for 26@30 deg. Baumé, 5¼c.; Diesel 32@34 deg., 6c. per gal.; distillate 38@42 deg., 7c. per gal.

Cleveland — Dec. 21, 26@30 deg. Baumé, 4¼c. per gal.

New Plant Construction

PROPOSED WORK

N. Y., Hornell—The Dairymen's League of Hornell plans to build a milk condensing plant here. About $200,000.

N. Y., New York—The Bd. Educ., 500 Park Ave., plans to build a 5 story high school on 2nd Ave. and 67th St. About $1,000,000. C. B. J. Snyder, 28th Floor Municipal Bldg., Archt. and Engr.

N. Y., New York—The Bd. Educ., 500 Park Ave., will soon receive bids for a P. S. No. 139 on 139th St. and Lenox Ave. About $850,000. C. B. J. Snyder, 28th Floor Municipal Bldg., Archt. and Engr.

N. Y., New York — Margon & Glaser, Archts., 2806 3rd Ave., has completed plans for a 5 story apartment on 230th St. and Kingsbridge Ave. About $450,000. Owner's name withheld.

N. Y., New York—F. M. Schildwachter, c/o Koch & Wagner, Archts., 32 Court St., Brooklyn, is having plans prepared for an ice plant on Webster Ave. and 174th St. About $750,000.

N. Y., New York—Trowbridge & Livingston, Archts., 512 5th Ave., will receive bids until Jan. 5 for a 23 story bank and office building on Wall, William and Pine Sts. for the Bank of America, 44 Wall St. About $2,500,000. Noted Nov. 15.

N. Y., New York—The U-Need Ice Co., 2050 Amsterdam Ave., will soon receive bids for an ice plant on Inwood Ave. About $250,000. Koch & Wagner, 32 Court St., Brooklyn, Archts. and Engrs.

N. Y., Marcy—The State Hospital Comm., Capitol, Albany, received bids for a cold storage building and kitchen for the Marcy State Hospital from A. J. Burgess Co., Utica, $130,970; the Shane Constr. Co., 302 Herald Bldg., Syracuse, $155,744; and R. Richards & Son, 246 Elizabeth St., Utica, $166,500. Noted Dec. 13.

N. J., Secaucus (Weehawken P. O.)—(Change of date)—The Bd. Freeholders, W. O'Mara, Clk., will receive bids until Jan. 12 for a 2 story insane asylum, consisting of several buildings, including a power plant on County Farm. Cost between $750,000 and $1,000,000. J. T. Rowland, Jr., 100 Sip Ave., Jersey City, Archt. Noted Dec. 20.

Pa., Philadelphia—The city will receive bids until Jan. 6 for furnishing and placing high pressure steam and water pipe, exhaust lines, covering for pipe, flange and check valves, 10 in. oil separator, 3 separators, extra pipe specials, etc., and construction of foundations for pumping station at Belmont Pumping Station. Total cost, $43,000; also laying cable Roxboro & Belmont pumping stations. About $30,000. C. E. Davis, City Hall, Engr.

Pa., Philadelphia—T. W. Laub, Archt., 644 8th St., New York City, is receiving bids for a 16 story, 129 x 129 ft. theatre and office building on 16th and Market Sts., here, for the Fox Film Corp., 126 West 46th St., New York City. About $1,000,000.

Pa., York—The School Bd., c/o C. M. Crider, is having plans prepared for a 3 story, 235 x 245 ft. high school on Beaver and College Sts. About $350,000. H. E. Whitman, Hamme City Bank Bldg., Archt.

Ga., Augusta—The Treasury Dept., J. A. Wetmore, Acting Supervising Archt., Washington, D. C., will receive bids until Jan. 18 for the installation complete of the mechanical equipment for the boiler house, 4 continued treatment buildings, 1 disturbed patients' cottage, 1 kitchen and mess hall building, the connections to present building and certain outside services at the United States Public Health Service Hospital No. 62, here.

La., Bogalusa—The Bogalusa Paper Co., subsidiary to Great Southern Lumber Co., Whitney Bldg., New Orleans, plans to build

an addition to paper mill here. About $1,000,000. W. H. Sullivan, Genl. Mgr.

La., New Orleans — H. K. Johnson, Hebermin Book Bldg., has been granted a franchise to build an electric light and power plant.

La., New Orleans—The Treasury Dept., J. A. Wetmore Acting Supervising Archt., Washington, D. C., will receive bids until Jan. 16 for an ice making and refrigerating plant for the United States Quarantine Station here.

O., Cleveland — S. H. White, Schofield Bldg., will receive bids until Jan. 4 for a 9 story, 80 x 350 ft. apartment, including a steam heating system on East 116th St. and Shaker Blvd., for The Chester Gardens Co. About $2,500,000. Noted Nov. 8.

O., Dayton — Marcus Lowe Inc., 1540 Bway., New York City, is having plans prepared for a theatre and office building here. About $500,000. T. W. Lamb, 644 8th Ave., New York City, Archt. and Engr.

O., Dayton—The Terminal Cold Storage & Ice Co., c/o B. & C. Baking Co., 233 Clinton St., is having plans prepared for an 8 story, 135 x 150 ft. refrigeration plant on Eaker and Ludlow Sts. About $500,000. G. B. Bright Co., 103 Marquette Bldg., Detroit, Mich., Archts.

Ind., Ft. Wayne—The Pennsylvania Line West of Pittsburgh, Pennsylvania Station, Pittsburgh, plans to build a 2 story, 82 x 180 ft. machine and boiler shops. About $400,000. R. Trimble, Pennsylvania Station, Pittsburgh, Engr.

Ind., Indianapolis—H. N. Maloney Apartment Co., c/o E. I. Smith, of Emerson W. Chaille Co., 921 Hume-Munsen Bldg., plans to build an apartment on 34th and Meridian Sts. About $350,000. Private plans.

Ind., Indianapolis — The Pennsylvania Apartment Hotel Corp., 914 Hume-Mansen Bldg., will receive bids until Jan. 8 for a 6 story, 52 x 178 ft. apartment, including a steam heating system on North Pennsylvania Ave. About $300,000. W. K. Eldridge, 914 Hume-Mansen Bldg., Archt.

Ind., Lafayette—The Purdue University, Student Union, plans to build a 2 story students' union building. About $1,000,000. Pond & Pond, 64 East Van Buren St., Chicago, Ill., Archts.

Mich., Ann Arbor—The Michigan Athletic Assn., Prof. R. W. Aigler, plans to build a 160 x 300 ft. gymnasium, including a swimming pool, also a steam heating system. About $250,000. Architect not selected.

Mich., Detroit—The Detroit Branch of the Federal Reserve Bank of Chicago, West Congress St., Detroit, plans to build a 4 or 6 story, 100 x 160 ft. bank building, including a steam heating system on Fort and Shelby Sts. About $750,000. Architect not selected.

Ill., Chicago—J. A. Carroll & Bro., 1533 East 53rd St., having plans prepared for a 10 story, 140 x 170 ft. hotel "East End Park," including a steam heating system on N. W. Hyde Park and 53rd Sts. About $2,000,000. W. P. Doerr, 28 East Jackson Blvd., Archt.

Ill., Chicago — L. J. Rubin & Co., 214 South Market St., is having plans prepared for a 4 story, 141 x 187 ft. store and hotel building, including a steam heating system on Howard St. and Bosworth Ave. About $350,000. Loewenberg & Loewenberg, 111 West Monroe St., Archts.

Ill., Harvey—Ongalls, Sheppard Division of the Wyman Gordon Co., is having plans prepared for a power plant. About $100,000. H. Johnson, c/o owner, Engr.

Ill., Joliet—B. J. Bruns, Archt., 1548 Belmont Ave., Chicago, will receive bids about Jan. 15 for a 9 story apartment hotel, including a steam heating system. About $500,000. Owner's name withheld.

Wis., Beaver Dam—The city will soon receive bids for furnishing and installing a centrifugal pump with motor in the pumping station. W. A. Gergen, City Clk. Private plans.

Wis., Fond-du-Lac—The St. Agnes Hospital, c/o F. S. Wiley, 100 East Division St., purchased a site and plans to build a 4 story, 200 x 250 ft. hospital unit. About $500,000. Architect not selected.

Wis., Madison—W. F. Devine, U. S. Post Office Bldg., plans to build a 4 story, 60 x 210 ft. federal building, including a steam heating system, on Mifflin St. About $500,000. Architect not selected.

Wis., Menasha — The Menasha Wooden Ware Co. plans improvements to power and heating plants. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs.

Wis., Oshkosh — The city, c/o W. F. Porath, City Hall, is having plans prepared for a heating system, including boilers (350 hp.) for the Merrill School, here. About $25,000. Private plans.

Wis., Waupun—The Bd. Educ., c/o B. Kastern, Clk., plans to build a 4 story, 65 x 200 ft. high school, including a steam heating system. About $300,000. Architect not selected.

Wis., Wauwatosa—The Milwaukee County Bd. of Trustees received bids for a 2 story, 87 x 154 ft. cold storage plant on Watertown Plank Rd. from Jahns & Knuth, 1915 Chestnut St., Milwaukee, $77,500; W. F. Tubesing, 130 Chestnut St., $87,000; and P. W. Bringe, 940 3rd St., Milwaukee, $99,892. Low bid received for ice machine from Westerlin & Campbell, 1113 Cornelia Ave., Chicago, Ill., $23,950.

Kan., Salina—The Masonic Temple Assn. is having plans prepared for a 6 story, 123 x 162 ft. temple. About $1,000,000. T. L. Condron Co., 53 West Jackson Blvd., Chicago, Ill., Archts.

Mo., Kansas City—The Bellerive Investment Co., 111 North 7th St., St. Louis, will soon award the contract for a 15 story, 110 x 203 ft. hotel, including a steam heating system. About $1,000,000. P. J. Bradshaw, International Life Bldg., St. Louis, Archt. Noted Nov. 29.

Mo., Kansas City—The Treasury Dept., J. A. Wetmore, Acting Supervising Archt., Washington, D. C., will receive bids until Jan. 12 for hydraulic freight elevator, pumping plant, etc., for extensions United States Post Office and Court House here.

Okla., Locust Grove—The city plans election Jan. 5 to vote $20,000 bonds for electric light system. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Consulting Engrs.

Cal., Eureka—The Bd. Supervisors, Humboldt County, is receiving bids for a power house and laundry for the county hospital here. About $10,000. N. Ackerman, 430 H St., Archt.

Cal., Los Angeles — The County Bd. of Supervisors is having plans prepared for an 11 story, 195 x 226 ft. county jail on Temple, Buena Vista and New High Sts. About $2,500,000. The Allied Archts. Assn., 1128 Citizens Bank Bldg., Archts.

Cal., Sacramento—The state will soon receive bids for two 5 story State Capitol buildings on the Capitol extension site. About $3,000,000. Weeks & Day, Phelan Bldg., San Francisco, Archts. and Engrs.

Cal., San Francisco—W. N. Moore & Co., 7 Front St., is having plans prepared for an 8 story wholesale dry goods building on S. E. Fremont and Mission Sts. H. J. Brunnier, Sharon Bldg., Engr., and G. W. Kelham, Sharon Bldg., Archt.

Ont., Cayuga—The Council, R. S. Colter, plans electric lighting and power system.

Ont., Charing Cross—The Council, A. E. Robinson, plans electric lighting and power distribution system. About $60,000. E. R. Lawlor, 190 University Ave., Toronto, Engr.

Ont., Hensall—The Council, H. Strang, plans electric light and power distribution system. About $30,000.

Ont., Kingston—A. Davis & Son, Ltd., is in the market for three 75 to 100 hp., 60 cycle, 3 phase, 550 volt motors.

Ont., North Bay—The Timiskaming & Ontario Rwy. plans to investigate the complete electrification of the railway, including extension planned from Cochrane north. S. B. Clement, North Bay, Ch. Engr.

Que., Montreal—T. Lovatt, 1537 St. Denis St., is in the market for one 25 hp. steam boiler.

Que., Montreal—The Mount Royal Arena, T. J. Duggan, Purch. Agt., is in the market for equipment for artificial ice plant.

Que., Quebec — The Canada Hotel Co., c/o A. Norcross, Ltd., 65 Victoria St., Montreal, has purchased a site and plans to build a 10 story hotel on St. Johns St. here. About $1,000,000. Architect not selected.

CONTRACTS AWARDED

N. Y., Brooklyn—Kellner Bros., c/o C. B. Meyers, Archt., 31 Union Square, New York City, will build two 5 story apartments on Eastern Pkway. and Washington Ave. About $600,000. Work will be done by separate contracts.

N. Y., Brooklyn—The Bd. Educ., 500 Park Ave., New York City, has awarded the contract for a P. S. No. 187 on 12th Ave. between 64th and 65th Sts., to the T. C. Clarke Co., 122 Livingston St., $543,600. Noted Dec. 6.

N. Y., New York—The Arrowhead Holding Co., 41 Convent Ave., will build a 5 story, 90 x 125 ft. apartment on Haven Ave. About $500,000. G. F. Pelham, 200 West 72nd St., Archt. and Engr. Work to be done by day labor.

N. Y., New York—The Estate of G. P. Johnson, Inc., 30 East 42nd St., will build six 5 story apartments on 156th St. and Leggett Ave. About $200,000 each. Work will be done by day labor.

N. Y., New York—M. J. Kramer, c/o G. F. Pelham, 200 West 72nd St., will build a 7 story apartment on Hamilton Place. About $750,000. Work will be done by separate contracts.

N. J., Palmyra — The School Bd. has awarded the contract for a 2 story, 124 x 154 ft. high school on 5th and Delaware Ave. to G. W. Shauer & Sons, Palmyra, $124,817. Heating and Ventilating system to the Mechanical Equipment Co., 1201 Sansom St., Phila., Pa., $27,744.

N. J., Jersey City—The Erie R.R., 50 Church St., New York City, has awarded the contract for a 1 story, round house consisting of 23 stalls, and addition to boiler plant, etc., on Pavonia Ave. to the Austin Co., Bulletin Bldg., Phila., Pa. $75,000.

Pa., McKeesport—The Y. M. C. A., 2 West 45th St., New York City, has awarded the contract for a 4 story, 115 x 170 ft. Y. M. C. A. building to Schutz, Schreiner & Clyde Co., May Bldg., Pittsburgh. About $535,000.

Pa., Philadelphia—The N. E. Church, c/o Bishop Berry, 1721 Arch St., has awarded the contract for an 8 story, 60 x 114 ft. addition to hotel and church on 17th and Arch Sts., to Cramp & Co., Deicla Bldg. About $500,000.

N. C., Charlotte—The Southern Power Co., has awarded the contract for a dam across Catawba River at Mountain Island and power house to develop 80,000 hp. at same place to Rinehart and Denny Co., Charlottevile, Va. About $8,000,000. A power plant at Great Falls, S. C., to Scott, Hewart & Jones Co., Greensville, S. C. About $4,000,000. Both contracts include installation of equipment. Noted Nov. 22.

N. C., Winston-Salem—The Bd. Trustees has awarded the contract for heating system for the Academic Arts building of the R. J. Reynolds Memorial High School to the Grinnell Co., Charlotte, $73,790.

O., Cleveland—L. W. Kelly, Hippodrome Bldg., has awarded the contract for a 12 story, 94 x 190 ft. apartment hotel on Euclid Ave. and East 107th St. to J. Gill & Sons, Citizens Bldg. About $1,500,000. A steam heating system will be installed. Noted Nov. 15.

Mich., Flushing—The Village will build extensions to water mains and install new pumping equipment. About $60,000. United Engr. Corp., 522 Griswold St., Detroit, Engrs. Work will be done by force account.

Ill., Chicago—The Tiffin Theatre Co., 4043 West North Ave., has awarded the contract for a 3 story, 72 x 105 x 200 ft. theatre at 4053-59 West North Ave. to the Home Constr. Co., 1743 North Crawford Ave. About $400,000. A steam heating system will be installed.

Minn., Minneapolis—Fleisher Constr. Co., 608 Builders Exchange, will build fifteen 3 story, 40 x 110 ft. apartment buildings. Cost between $50,000 and $60,000 each. Steam heating system will be installed.

Kan., Topeka—The Seymour Packing Co., 202 North Kansas St., has awarded the contract for a 3 story, 50 x 150 ft. cold storage plant to F. M. Spencer & Son, Mulvane Bldg. About $150,000. Ice machinery will be installed.

Kan., Wichita—The Wichita Ice & Storage Co., C. W. Southward, Pres., has awarded the contract for a 5 story, 75 x 90 ft. ice plant at 213 South Rock Island Ave. to H. I. Ellis Constr. Co., 927 North St. Francis Ave. About $200,000. Noted Nov. 8.

Tex., Dallas—Cary Schneider Investment Co., Gt. Sou. Life Bldg., has awarded the contract for an 18 story, 112 x 112 ft. office building on Masten and Pacific Sts., to G. W. Hewitt, Salughter Bldg. Total cost $1,000,000.

Okla., Duncan—The Modern Hotel Co., c/o W. C. MacCready, Pres., Ballinger Bldg., St. Joseph, Mo., has awarded the contract for a 6 story, 140 x 140 ft. hotel, including electric light, water and refrigerating plants, etc., to E. H. Lawhon, 905 Edmond St., St. Joseph, Mo. About $500,000. Equipment to cost about $200,000 will be installed.

Cal., Santa Barbara — The St. Frances Hospital has awarded the contract for a 3 and 4 story, 40 x 190 and 40 x 90 ft. hospital to J. Y. Parker, 610 Live Oak St. About $215,000. Contract for a power plant and laundry building will be awarded later.